

A CLASSIFICATION AND GLOSSARY
OF LAND FORMS AND PARENT MATERIALS

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by

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PURDUE UNIVERSITY
LAFAYETTE INDIANA

Final Report

A CLASSIFICATION AND GLOSSARY
OF LAND FORMS AND PARENT MATERIALS

TO: K. B. Woods, Director
Joint Highway Research Project

FROM: H. L. Michael, Assistant Director
Joint Highway Research Project

June 21, 1961

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A final report "A Classification and Glossary of Land Forms and Parent Materials" by Ronald Lee Terrel is attached. Mr. Terrel also utilized the report for his MGS thesis. The project was conducted under the direction of Professor Robert D. Miles.

Land forms and associated parent materials have been utilized in the interpretation of terrain for various engineering purposes. Because of lack of background in the earth sciences, some confusion has existed in the use of land forms and parent materials. To assure uniform usage the terms have been separated and defined in glossary form. Emphasis has been placed upon those terms useful in airphoto interpretation of land forms and parent materials. Where feasible, the terms have been classified in a simple, but logical manner so as to make identification easier.

The report is presented to the Board for the record.

Respectfully submitted

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A CLASSIFICATION AND GLOSSARY
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by

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File: 1-4-18

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June 21, 1961

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ABSTRACT

Terrel, Ronald Lee. MSCE, Purdue University, June, 1961. A Classification and Glossary of Land Forms and Parent Materials. Major Professor: Robert D. Miles.

Land forms and associated earth materials, recorded as patterns on aerial photographs have been utilized in the interpretation of terrain for various engineering purposes. Many engineers recognize significant differences in these features, but lack of background in the various earth sciences has made it difficult for them to translate their meaning into useful engineering data. A common mistake has been that of confusing land forms and parent materials.

In this paper, the two groups of terms, land forms and parent materials, have been separated and defined in glossary form. In the selection of terms to be defined, emphasis has been placed upon those useful in airphoto interpretation. Where feasible, the land form and parent material features have been classified in a simple, but logical manner so as to make identification easier.

INTRODUCTION

In the location, design and construction of transportation systems and engineering structures, the engineer faces a diversity of problems. These are to a great extent concerned with the topographic characteristics of the natural terrain, and the physical properties and structures of the associated earth materials. These characteristics, in conjunction with the earth materials, can be subdivided and identified as particular features, commonly called land forms.

There are basically four methods by which information can be obtained for making preliminary engineering studies. These methods are: (1) the use of aerial photography; (2) the use of agricultural soil survey maps; (3) the use of geological maps; and (4) the use of topographic and planimetric maps.

In areas where topographic, soil-survey, and geologic maps as well as aerial photographs are available, preliminary analysis of an area may be carried out if the engineer or soils surveyor can translate the terminology and mapping units into useful engineering data. Often, however, a true surface-material picture is not comprehended because of non-familiarity with literature and maps of this type. The confusion may result because of inability to translate the literature used by the soil scientist, geologist, and others in the field of earth sciences into his own terminology.

A common example of such confusion is the practice of describing

a land form using a parent material term. For instance, limestone has been used (11, p. 11)* as a land form term whereas one of the terms karst plain or karst valley might have been more appropriate. Land form also often has been used in reference to merely topographic features. However, just as species of plants and animals have their diagnostic characteristics, so land forms have their individual distinguishing features dependent upon the geomorphic process and geologic conditions responsible for their development.

The simple fact that individual geomorphic processes acting on the local geologic conditions do produce distinctive land features makes possible a genetic classification of land forms. It doubtless would be possible to describe the multitudinous land forms in terms of perhaps a dozen or fifteen primary or elemental forms such as plain, slope, scarp, ridge, table, column, depression, valley, trough, peak, arch, and cavern; but in general such terms tell little or nothing about the origins of the forms or the geologic history of the regions in which they exist. Much more illuminating are such terms as floodplain, fault scarp, sinkhole, sand dune, and wave-cut bench. Even though they are in part descriptive, they have genetic implications.

These facts tend to indicate that a common language, or at least a common source of information, concerning the terminology as it refers to the Civil Engineer, is needed. Many, if not most, of the terms found in the literature, however, are quite unfamiliar to the average engineer. A glossary with concise, yet applicable definitions of

* Numbers in parentheses refer to references listed in the Bibliography under References Relating to Land Forms and Parent Materials

mapping units would be of great value to the engineer, particularly one versed in the art of airphoto interpretation.

It is with this purpose in mind that the writer has investigated the literature and attempted to prepare a classification and glossary for each of the two topics, land forms and parent materials. The glossaries are intended to be comprehensive only to the extent as to be useful to the engineer as applied to airphoto interpretation of land forms and associated soils and rocks. Also, it is desired that this report be useful to the student in the classroom, the materials prospector, the location engineer, or the analyst who is preparing an engineering soils map. Through the use of these glossaries it is hoped that a common language is developed such that the work of one investigator can be easily and accurately correlated with the work of another. The information on an engineering soils map of one area could easily be continued into the adjacent area if it was developed by using a common land form language and the same map units.

CLASSIFICATION AND GLOSSARY OF LAND FORMS

A land form may be defined as the repetitive expression of a land unit, including topography, relief and shape, that reflects the geomorphic processes involved in its development as well as the materials of which it is composed. As pointed out in the Introduction, a land form term should express an idea as to its geomorphic history and general nature of materials as well as form.

Topography is the general configuration of the land surface, including its relief. The term relief has also been considered somewhat synonymous with topography, referring to the collective elevations of the inequalities of the land surface. More specifically, considering a local area, relief is the vertical distance between the highest and the lowest elevations.

Considering these factors of topography, relief, and regional extent, seven first order shapes are recognized: mountains, hills, ridges, plateaus, plains, basins, and valleys. These have been incorporated as the ordinate of the land form classification chart which is presented in Table 1. Another category, miscellaneous, includes those forms that do not readily fit into one of those mentioned above. These seven basic terms are defined in the following paragraphs.

1. A mountain is any part of a land mass that projects conspicuously above the surrounding area and has a small summit area as compared to a plateau. The difference between a hill and a mountain is relative.

However, a mountain can generally be considered to have local relief of at least 1000 feet.

Isolated mountains of varied origin are common in all parts of the earth, but most mountains are parts of larger groups which show notable differences in size, elevation, relief, origin and age. In describing the larger mountainous complexes, the terms range, system, chain and cordillera are commonly used.

A mountain range consists of a single, large, simple or complex ridge, or of closely spaced ridges which are similar in direction, age, and origin. A mountain system includes a group of ranges more or less similar in form, structure, and alignment. A mountain chain includes ranges and systems without similarity of form, structure, or origin. Cordillera is a comprehensive term describing a group of chains, systems and ranges that make up a more or less compact zone of vast extent.

2. A hill is a natural elevation of land usually of limited extent and of rounded rather than peaked or precipitous form. The term is more or less relative as there is complete gradation between hills and mountains. In general the term hill is restricted to more or less abrupt elevations of less than 1000 feet of relief, all altitudes exceeding this being mountains.

Some hills, like some mountains, are volcanic heaps, and many, like mountains, are produced by dissection of plateaus and plains; but none are the direct result of uplift. The term includes depositional as well as erosional features, the Sand Hills area of Nebraska being a good example.

3. A ridge is a narrow, elongated crest of a hill or mountain. Generally the length of a ridge exceeds the width by several times. The

elevation can range from a few feet to several thousand feet and still be considered under the general term, ridge.

Ridges only exceptionally owe their superior altitude to uplift. Much more regularly they exist as isolated, high masses because they are composed of material, or have a structure, that is more resistant to degradational attack than that of the surrounding areas. The above definition would also include forms of recently deposited material of an unconsolidated nature such as eskers, ridge moraines, and longitudinal sand dunes.

4. A plateau is a flat-topped area, or "table-land", of considerable extent elevated above the surrounding country on at least one side. It may have a plane or an undulating surface, and is dissected by deep canyons and valleys. In general, the term should be restricted to land forms having horizontal underlying strata. A plateau has local relief of 500 feet or greater.

Defining the term plateau can be troublesome if its general concept as a highland is not recognized as being only relative. Most plateaus are situated on the flanks of or between mountain ranges, and are definitely related to such ranges in their origin. Both represent regions that have been uplifted by earth movements. The uplifted surface may be highly dissected by canyons, hence the term dissected plateaus.

5. A plain is a comparatively flat, smooth and level area. It is limited to less than 500 feet of local relief and generally the underlying structure is of a horizontal nature. The material underlying a plain may be either consolidated or unconsolidated. The areal extent of a plain is often considered to be large, however, smaller areas may

also be classified as a plain. For example, floodplain, alluvial plain, and lacustrine plain all are relatively small compared to the Great Plains stretching eastward from the Rocky Mountains, however, they all fit the definition given above.

The term plain used alone generally brings to mind only a topographic feature and therefore is, in most cases, used with another term which helps to further classify it. For example, the land form terms floodplain and outwash plain give an indication of the origin and nature of the underlying material as well as some idea as to relative size. A dissected plain is the term given to a plain that has been highly dissected by stream action.

6. A basin is a depression in the earth's surface, varying greatly in size, into which the adjacent land drains, and having no surface outlet. This definition includes features which vary in shape and origin. Origins include: crustal deformation, volcanic action, glaciation, rivers, subsurface water, winds, landslides, meteorites, and man-made. The term has also been used to describe the drainage area of a large river and its tributaries, however, the term watershed is more appropriate in this instance. As used and defined above, the term basin is limited to a closed, negative topographic feature.

In structural geology, the term basin is a syncline that is circular or elliptical in plan. The outcrop of each formation is essentially circular or elliptical, and the beds dip inward.

7. A valley is an elongated depression on the surface of the earth cut by running water, with an outlet, margined by areas of higher land. It may be broad and shallow, or narrow and deep. Most valleys contain either perennial or intermittent streams, though some are occupied by

lakes, salt pans, or glaciers.

A level tract of great extent, and traversed by more rivers than one, should be termed a plain rather than a valley. Considering their relative depth, width and length, valleys have special names to describe them. For example, at the headward end of a stream system, the short, steep valleys are termed gullies. Deep, narrow valleys generally containing a swift-running river are called canyons, while a small canyon can be called a gorge. They are also known by other such names as draw, ravine, gulch, hollow, run, arroyo, or by more poetic forms such as vale, glen, and dale, but the one thing that is common to all is that they were cut by running water.

As a region passes through the geomorphic cycle, the valleys also exhibit changes, going from youth, through maturity, to old age. A common misuse of terms has been to use valley and stream as though they were synonymous. The terms young stream, mature stream and old stream have been used when actually young, mature and old valleys were intended. The stage in the life of the river or valley at any given moment is usually not the same as the stage of development of the region. It is possible to have an old stream in a young valley or a young stream in an old valley, for young, mature, and old as applied to a valley have no time implications but rather imply certain characteristics of the valley which are diagnostic to its stage of development.

Valley width is the linear distance between valley sides and is expressed in terms of the cross section of a valley. Valley lengthening may take place in three ways; (1) headward erosion, (2) increase in size of their crooks or meanders, and (3) lengthening their termini. It is generally recognized that there is a downward limit to valley deepening

known as base level.

To complete the concept that a land form should also be recognized as to origin, as well as topography, the chart is further divided into nine such origins of the topographic expressions defined above. These are: plutonic, volcanic, tectonic, remnantal, eolian, gravitational, glacial, fluvial, and lacustrine or marine. These are briefly defined as follows:

1. Plutonic refers to igneous rock magma that has cooled and solidified at great depths and which later becomes exposed by erosion.
2. Volcanic, in contrast to plutonic, refers to molten rock masses that have cooled and solidified at or very near the earth's surface.
3. Tectonic pertains to the rock structures and external forms resulting from the deformation of the earth's crust.
4. Remnantal land forms are the earth masses that have remained intact as erosion has removed surrounding terrain.
5. Eolian pertains to both erosional and depositional land forms and materials that are a direct result of wind action.
6. Gravitational refers to those features that are formed by the action of gravity.
7. Glacial pertains to features formed directly or indirectly by the action of glaciers.
8. Fluvial land forms are those produced by stream action.
9. Lacustrine or Marine refers to both erosional and depositional features formed in the environment of lakes or the sea, whether they are within the lake or sea proper, or along their periphery.

These origins are often called geomorphic processes - all those

physical and chemical changes which effect a modification of the earth's surficial form. Geomorphic processes leave their distinctive imprint upon land forms, and each geomorphic process develops its own characteristic assemblage of land forms. This fact makes possible a genetic classification of land forms. The land forms considered to be most important in airphoto interpretation are briefly defined and discussed in the following glossary.

TABLE 1. CLASSIFICATION OF LAND FORMS

	PLUTONIC	VOLCANIC	TECTONIC	REMANTAL (erosional)	EOLIAN	GRAVITATIONAL	GLACIAL	FLUVIAL	LACUSTRINE & MARINE
Mountain	Batholith Exfoliation dome Stock Pluton	Basalt cone Basalt dome Composite volcano	Block mountain Horst Massif	Bornhardt Exfoliation dome Mesa Monadnock Table mountain			Horn		
Hill	Batholith Boss Exfoliation dome Steptoe Stock Pluton	Basalt cone Basalt dome Cinder cone Fumerole Geyser cone Lava blister Mud volcano Plug dome Spatter cone Strato volcano Tuff ring Tumulus Volcanic neck	Dome Salt dome	Bornhardt Butte Exfoliation dome Flatiron Haystack Inselberg Mesa Monadnock Needle Pedestal rock Pepino hills Pinnacle Volcanic neck	Barchan Clay dune Dune Loess Hill	Talus cone	Drumlin Esker delta Kame Nunatak Roche moutonnée Rock drumlin	Alluvial fan Alluvial cone	Chimney Headland Island Sea arch Sea stack
Ridge	Dike ridge Palisade Sill ridge	Lava coulee Pressure ridge	Anticlinal ridge Cuesta Fault-line scarp Fault scarp Homoclinal ridge Piedmont scarp Strike ridge Synclinal ridge	Hogback	Dune ridge Loess ridge Longitudinal dune Seif dune Transverse dune Whaleback Yardang	Earth flow	Arete Col Crevasse filling End moraine Esker Interlobate moraine Kettle-kame moraine Lateral moraine Recessional moraine Ridge moraine Terminal moraine	Alluvial scarp Erosional escarpment	Atoll Bar Barrier bar Barrier beach Barrier reef Bay bar Beach ridge Coral reef Fringing reef Hook Isthmus Off shore bar Sea cliff Spit Tombolo Winged headland
Plateau	Shield	Lava plateau Shield volcano	Plateau	Plateau	Loess plateau				
Plain	Shield	Lava plain Malpais Scabland	Plain	Plain Peneplain	Desert pavement Erg Cassi Hammada Loess plain		Esker delta Ground moraine Outwash plain Pitted outwash plain Till plain	Alluvial apron Alluvial fan Alluvial plain Arcuate delta Bajada Baselevel plain Delta Digitate delta Estuarine delta Flood plain Fluvial plain Karst plain Pediment Piedmont plain Piedmont slope River terrace	Beach Bayhead beach Continental shelf Coastal plain Crescent beach Lacustrine plain Marine terrace Muck plain Muskeg Salina plain Shingle beach Wave-cut bench
Basin		Caldera Crater Lava pit Maars Nested craters Volcanic sink	Block basin Graben		Blowout Loess sink Parabolic dune		Cirque Finger lake Kettle Pasternoster lakes Tarn Trough lake	Bayou Bolson Collapse sink Delta lake Doline Oxbow lake Pothole Sinkhole Slough	Alkali flat Bay Bog Cove Gulf Lagoon Marsh Playa Swamp Wallow
Valley	Dike valley Sill valley	Lava tunnel	Anticlinal valley Homoclinal valley Rift valley Strike valley Synclinal valley			Avalanche Debris avalanche Debris fall Debris slide Earth flow Landslide Mudflow Rock glacier Rock slide	Esker trough Fjord Glacial trough Hanging valley Valley train	Amphitheater Arroyo Badlands Box canyon Coulee Draw Drowned valley Estuary Gap Meander Natural levee Rill River bar Sandwash Solution valley Water gap Watershed Wind gap	
Misc.			Fault Joint Triangular facet	Crets		Catsteps	Erratic Triangular facet	Cave Cavern	

GLOSSARY OF LAND FORMS

ALKALI FLAT. A lacustrine plain or basin in an arid or semi-arid region where alkali salts have become concentrated by evaporation of lake water and poor drainage. The so-called white alkalies consist mostly of sodium sulphate, the black alkalies are made up chiefly of sodium carbonate. In general, the alkalies are any bitter-tasting salt found at or near the surface of the ground in arid regions.

When excess surface water accumulates in the lowest depressions, the arid conditions cause rapid evaporation and surface deposits of fine sediment and minerals remain as a level lake-like plain. If mechanical sediments rather than chemical precipitates prevail, the surface is generally smooth and hard, but the presence of efflorescent or hygroscopic salts may leave the surface soft and pasty. The term salina plain is sometimes used as a synonym. See also PLAYA and LACUSTRINE PLAIN. (4, 29, 89)

ALLUVIAL APRON. The smooth alluvial slopes which border desert mountains and extend downward to neighboring basin floors. This slope commonly consists of two components, a lower part of aggradational origin, called a bajada, and an upper part which is really an eroded bedrock surface, although it is commonly veneered with alluvium. This upper part is generally called a pediment, although various names and origins have been suggested. The terms piedmont slope or piedmont plain

(also piedmont alluvial plain) have been used synonymously with alluvial apron. (89, 92, 101)

ALLUVIAL FAN. A sloping, fan-shaped mass of loose, unconsolidated material deposited by a stream at the place where it emerges from an upland into a broad valley or a plain. The highest point is at the apex of the fan, which is generally composed of boulders and cobbles and gravel that are dropped where the gradient of the stream decreases as it emerges from its confining canyon walls. The slope of the surface near the apex may be as much as 300 feet to the mile, (89) but it decreases toward the outer limit to as little as 10 feet to the mile. If the fan has steep slopes (greater than 30 degrees) it is generally called an alluvial cone. The union of two or more alluvial fans forms a compound fan and a series of compound fans along a mountain front or plateau escarpment forms an alluvial apron. (92, 101)

During the process of fan building, the stream flowing over its surface may change its position many times. In fact, at the fan head the main stream may divide into several distributaries which may sink into the fan to emerge as springs several miles below at the foot of the slope. The fan surface, therefore, is characterized by an interlacing network of braided channels, usually dry except immediately after a torrential downpour in the mountains above.

In semi-arid and arid regions, where streams dwindle rapidly in size after they leave mountain canyons, alluvial fans and aprons are conspicuous features of piedmont landscapes and often bury large areas. In humid regions where permanent streams prevail fans normally are built of finer sediments, have more gently sloping surfaces,

and thus are much less conspicuous. Fans also are more prominently developed in regions of steep slopes than where the slopes are gentle because of the need for a gradient change along the stream profile.

ALLUVIAL PLAIN. A surface built up by the deposition of alluvium usually lateral to a river which periodically overflows its banks. The slope of such a plain is usually gentle but it may grade upward into an alluvial fan or alluvial apron having notably steeper slopes.

Variations in velocity of a stream changes its load-carrying capacity and the swifter part may obtain a load which the slower part cannot carry. Deposits will then be made in the valley where the current is sluggish. Alluvial plains constructed in this way are called floodplains.

Alluvial plains, as described above, may be very similar to alluvial aprons but are generally considered to have a relatively less steep gradient than do alluvial aprons or fans, and are usually confined between valley walls. (4, 53, 92)

ALLUVIAL SCARP. See ESCARPMENT.

AMPHITHEATER. A relatively flat-bottomed valley at the headward end of a stream, with walls rising steeply in a semi-circular plan outline.

The heads of most gullies in arid plateaus are wide amphitheatres, instead of sharp-pointed ravines as they are in humid regions. The term amphitheater is also used synonymously with cirque, a term which implies not only shape but also origin.

ANTICLINAL RIDGE. A mountain ridge resulting either from original upwarping of the earth's surface, or due to the removal of surrounding

weaker material by erosion.

An anticline is a folded portion of the earth's crust that is convex upward or is inferred to have had such an attitude at some stage in its development, in more complicated folds. An anticline may also be defined as a fold with the older rocks toward the center of curvature. The word is from the Greek; it means "opposite inclined". It refers to the fact that, in the simplest anticlines, the two sides or limbs dip away from each other. In some anticlines, however, the two limbs dip in the same direction, or horizontal in each case, retaining the oldest rocks in the central part of the fold. Still other anticlines have attained such a complicated form that no simple definition can be given.

A line where the folded beds show the maximum curvature is called the axis of the anticline. In some anticlines the axis is horizontal while in others the axis is inclined. When the axis is inclined, the anticline is said to plunge, or the folded rock layers disappear or plunge beneath the land surface along the axis. Although the larger plunging folds cannot be directly observed, they are easily recognized from their outcrop pattern, particularly in arid regions. The individual beds of rock tend to converge to form a "canoe shaped" point at the crest or most convex part of the fold, hence the term plunging anticline or a pitching anticline. A doubly-plunging anticline is one that reverses its direction of plunge within the area under discussion, giving an elliptical map outline of the rock layers. A doubly-plunging anticline that has no distinct axial trend is called a dome. (4, 12)

ANTICLINAL VALLEY. A stream valley that is due to erosion and follows the axis of an anticline. An anticlinal valley represents the reversal of topography, for such a valley now occupies the site of the former ridge as a result of erosional breaching of the crest. See **ANTICLINAL RIDGE.** (4, 12)

ARCHIPELAGO. A considerable number of islands grouped or clustered together. "The Archipelago" is the name applied to the sea between Greece and Asia Minor, and not to the islands contained in it. (4)

ARCUATE DELTA. See **DELTA.**

ARETE. An acute and rugged sawtooth-like ridge in glaciated mountains. It consists essentially of alternating segs or cols produced by intersection of opposed cirques and pointed peaks or horns representing unreduced portions of the original mountain range. While valleys are being enlarged the crests of the mountains are sharpened by frost wedging. The continued growth of cirques on opposite sides of a crest eventually reduces the crest to a knife-edged form kept sharp by frost wedging. As a result the mountain range develops a sharp main ridge with sharp lateral spurs. Other terms that have been used to describe an arete are serrate ridge and combe ridge. (43, 89, 92)

ARROYO. A gully or channel of an ephemeral or intermittent stream, usually in an arid region. Typically it is cut in unconsolidated material and has steep vertical walls at least two feet high. Arroyo is the term commonly applied to the deep washes at the mouths of mountain canyons - in the upper portion of alluvial fans. In periods of heavy rainfall it may be full of water at which times it is

enlarged and lengthened. The term is sometimes applied to the discontinuous or intermittent stream which occupies such a channel. The term is generally confined to the Southwest as is the near-synonym barranca. The Arabic equivalent is wadi. (4, 89)

ATOLL. A ring of coral and algal reef rock formed in the sea, commonly represented as having a circular outline, but which may be of almost any closed pattern, surrounding a shallow lagoon. The reef rises only a few feet above sea level, and is, in relation to the diameter of the ring, very narrow. It is interrupted at one or many places by gaps (tidal inlets) through which the tide flows and ebbs. The atolls, and reefs in general, are limited geographically to tropical seas, especially the South Pacific Ocean. Many variations of the fundamental type are found. Some are nearly atolls but have a small island of non-reef origin, usually volcanic, within a lagoon; some are large reef masses without lagoons; some are submerged reefs; and small round or oblong reefs with enclosed lagoons called faros may form part of a larger barrier reef or atoll rim. Atolls are sometimes referred to as reef rings. See REEF. (92, 53, 104)

AVALANCHE. See LANDSLIDE.

BADLANDS. An area, large or small, characterized by extremely intricate and sharp erosional sculpture. Badlands usually develop in areas of soft sedimentary rocks such as shale but may also occur in decomposed igneous rocks, loess, etc. They occur chiefly in arid or semi-arid climates where the rainfall is concentrated in sudden heavy showers. The divides are sharp and the slopes are scored by intricate systems

of ravines and gullies. Fantastic erosional forms are commonly developed through the unequal erosion of hard and soft layers. Vegetation is scanty or lacking and there is a notable lack of coarse detritus. They may, however, occur in any region where vegetation has been destroyed or where soil and coarse detritus are lacking. (89)

BAJADA. See ALLUVIAL APRON.

BAR. A low ridge containing predominantly sand-sized material that is built into a submerged or emergent embankment on the floor of a lake or sea by waves and currents. The term bar used alone is not very distinctive. Therefore, specific names are given to individual forms, depending upon their forms and position.

Offshore bars or barrier bars are low ridges roughly parallel to, but not connected to the shore. They originate in shallow water as storm waves breaking some distance from shore pile the bottom sands into ridges. The term barrier bar should not be confused with barrier reef which is a feature formed by the growth of marine organisms. However, barrier beach has been used although it is not actually a beach.

A spit is a low ridge of sand attached to land on one end and terminated at the other end in open water of a bay. It grows outward from the lee side of a projecting headland if there is a sufficiently plentiful supply of coarse waste either broken from the headland itself by marine erosion or carried by longshore currents from some more distant source. Most commonly the axis of a spit will extend in a straight line parallel to the coast, but, where currents are deflected landward or where unusually strong tides exist, growth of

a spit may be deflected landward, with the resulting creation of a recurved spit or hook. Complex conditions and several stages of hook development may produce a compound recurved spit or compound hook.

Bars formed in or across bays have been given various names depending on their position. Baymouth bars connect headlands across the mouths of bays, while mid-bay and bayhead bars are located inside the bay as their names imply.

The term tombolo is used to denote bars that connect islands or connect islands to the mainland. Convergence of two spits offshore or recurving of a simple or compound spit until it becomes attached to shore produces a cusped bar.

River bar is a special use of the term bar and is a deposit of sand and gravel along the banks of a stream as well as those in the more central areas of the channel. (4, 92, 37)

BARCHAN. See DUNE.

BARRANCA. See ARROYO.

BARRIER BAR. See BAR.

BARRIER REEF. A low ridge of organic reef rock that lies off the coast of a land mass and is separated from it by a lagoon usually too deep to permit coral and algal growth. In exceptionally clear water, they may grow at depths as great as 300 feet but they are seldom found below depths of 150 to 200 feet. (92)

A reef, called the Great Barrier Reef, extends, practically uninterrupted, for a distance of almost 1000 miles parallel to the

northeast coast of Australia at a distance of approximately 50 miles offshore. Between the reef and the shore line the water is shallow, averaging about 100 feet in depth. See REEF. (53, 92, 104)

BASALT CONE. See VOLCANO.

BASALT DOME. See VOLCANO.

BASALT PLAIN. See LAVA PLAIN.

BATHOLITH. A very large mass of intrusive igneous rock, generally granite or granodiorite, cutting across the surrounding country rock, and showing no evidence of having a floor. The term is arbitrarily restricted to those bodies that occupy an area of more than 40 square miles. The roof is generally an irregular dome and the walls dip steeply outward so that the body enlarges downward. A batholith is almost always associated with mountain ranges, being exposed on removal of its rock cover. Roof pendants are projections of the overlying older rock down into the batholith. In plan, a roof pendant is completely surrounded by the rock of the batholith. Cupolas are isolated bodies of igneous rock that presumably connect downward with the main mass of the batholith. The term batholith is also spelled bathylith and batholite. (12, 92, 38)

BAY. An indentation in the shore line of a sea or large lake, similar to but smaller than a gulf, located between two capes or headlands. Generally a bay is considered to be the result of submergence of the topography rather than by marine erosion. Those smaller recesses in a shoreline resulting from differential marine erosion may be called

coves or bights. The more resistant rocks are left protruding seaward and are called headlands. See HEADLAND. (4, 29, 53)

BAYHEAD BEACH. See BEACH.

BAYOU. A term used locally in the lower Mississippi River basin and Gulf-coast region of the United States to mean a small sluggish stream, a lake, or a minor tributary stream in an abandoned channel or river delta. Another term meaning the same thing is bogue. (4, 89, 98)

BEACH. The gently sloping shore bordering a body of water that is washed by waves or tides and which consists of constructional materials such as sands and gravels. Strictly speaking, it is the temporary veneer of rock debris which accumulates along and on a wave-cut bench. The beach is a continuous or nearly continuous sheet and the graded profile of the surface extends landward from the low-tide to a level above high-water, where sand or gravel has been piled up by breaking waves. The term beach ridge or storm beach may be applied to the ridges formed by waves at their highest. The beach and beach ridge may not be permanent accumulations but may be cut away rapidly by wave action in response to changing conditions of weather or currents. Beach ridges are particularly striking ephemeral features along a shore line that is retreating seaward or along old shore lines of glacial lakes.

Beaches may extend continuously for hundreds of miles along a shore, as along the southeast coast of the United States, or they may be patchy. Along rugged shore lines, beaches are limited mainly to

strips at the heads of bays or coves and are known by various names such as bayhead beaches, cove beaches, pocket beaches, or crescent beaches. They also exist as strips of beach materials on the tips of headlands, and these are known as headland beaches.

Beach cusps are minor forms along shore zones consisting of sand, gravel, or coarse stones that are heaped together in rather uniformly spaced ridges which trend at right angles to the sea margin, tapering out to a point near the water's edge.

Beach sediments commonly consist of sand and silt or may be comprised of gravel or boulders around headlands or along cliff bases where coarse debris is abundant. In some places, the pebbles are much flattened and overlap each other to form a pavement or shingle beach. (92, 4, 65, 89)

BENCH. See WAVE-CUT BENCH, TERRACE.

BIGHT. See BAY.

BIRDS-FOOT DELTA. See DELTA.

BLOCK MOUNTAIN. A mountain which owes its form to faulting, generally being carved by erosion from large uplifted blocks bounded on one or more sides by fault scarps or slip faces. These mountains and the depressions or basins (block basins) between them make up the major features known as basin and range topography. The block basins or grabens are fault blocks which have dropped downward with respect to the horsts or blocks that have moved upward. The grabens are often called rift valleys when they are elongated and form the depression between two parallel faults or along a single fault break. More

often than not, the fault blocks have rotated or tilted upon faulting and are left as tilted fault block mountains. The eroded topography formed upon such a complex system often does not show direct evidence of faulting, scarps being eroded and the valleys filled with alluvium.

A mountain mass bounded by faults or fractures and displaced as a unit without internal changes is sometimes called a massif. (4, 12, 92)

BLOWOUT. A basin formed where the stabilizing vegetation is killed in various sand deposits and wind removes the sand. The material excavated frequently forms a crescentic ridge around the leeward side of the basin. Depending upon conditions associated with their development, blowout basins vary in ground plan from nearly circular to highly elongate. (53, 89, 92)

BLUFF. Same as ESCARPMENT.

BOG. See SWAMP.

BOLSON. A desert basin, more or less rimmed by mountains. The term generally applies to broad areas having centripetal drainage with a gentle gradient, including all the area within the limits of the divides. The floor of the bolson is covered with alluvium. (92, 53, 81)

BORNHARDT. An isolated mass of rock that emerges islandlike from a rock plain and has a summit that can vary from tens to a thousand feet or more above the surrounding surface. In general, bornhardts have bare,

domelike summits, their forms reflecting the internal rock structure (typically granite or gneiss). Their slopes steepen at the base and there is an absence of talus. Except that bornhardts are seemingly composed of the same rock as the plain or plateau surface, they could be considered monadnocks. (4, 101)

BOSS. See STOCK.

BOX CANYON. A canyon having nearly vertical walls and a zig-zag course. When it is viewed from its bottom, it appears to be enclosed by four high walls. Common in the Southwest, they are known as *cajons*. (98)

BRAIDED STREAM. A stream characterized by intertwining channels that branch and reunite. This condition is brought about by the stream being unable to carry its suspended load and the excessive deposition of material (sand and gravel) forces the water to flow in many branching channels. (89, 21)

BREACHED CONE. See VOLCANO.

BUTTE. A conspicuous, isolated hill or small mountain with relatively steep sides. Its origin is the same as that of a mesa, but a butte is limited in surface area to less than one-tenth of a square mile. A butte is capped with a protective covering of essentially horizontal beds.

Occasionally the term butte has been applied to similar small summits that were not, however, capped with horizontal strata. For instance, the volcanic features called plug domes and volcanic necks often are eroded to resemble buttes and should not be confused. A

general term, volcanic butte has been used to distinguish them.

A needle or pinnacle is somewhat similar to a butte in origin, being a detached mass of rock standing out from a cliff or scarp from which it has been severed by erosion. There is generally an absence of a summit area, the spire being very tall and slender, and often quite pointed at its top. The term needle is usually restricted to granite features. A Spanish term for such a group of pinnacles is candelas. See also PEDESTAL ROCK. (92, 29, 4, 89)

CALDERA. A large basin-shaped volcanic depression, more or less circular in form, the diameter of which is many times greater than that of the included vent or vents. Calderas of volcanic origin have been generally recognized as being of two types: explosive calderas and collapse calderas. A third type called erosion calderas has been recognized, but is generally restricted to the enlargement of craters and calderas due to erosion rather than used for any enclosed or walled basin, regardless of origin.

Explosion of a volcano may occur on such a large scale as to demolish a summit, forming the explosive caldera. Most volcanic craters which are similarly steep-walled and are of such great diameter as to enclose calderas have been found to be the results not of explosion, however, but of collapse and in-sinking of the tops of volcanoes, caused possibly by blowing-off or drawing-off of lava formerly filling reservoirs beneath the mountains. The details may differ; a single large cylindrical block may sink as a unit, or the collapse may be piecemeal, either during the eruption or immediately thereafter. See CRATER. (12, 102, 92)

CANOE-SHAPED MOUNTAIN. See ANTICLINE.

CANYON. See VALLEY.

CAPE. A general term for a point of land extending into a body of water. Similar to HEADLAND. (4)

CATSTEPS. A term used for small parallel ridge-like features that closely follow the contour of natural slopes. They have only a few inches of relief. They are found only where tree cover is lacking. One origin of these unique features is downslope movement as in solifluction, or in loess deposits where minor slumping produces a series of steps. Another cause in some areas is the use of steep, hilly land as pasturage for livestock such as sheep and cattle. Paths made by the animals mark the steep slopes with a step-like pattern. (4)

CAVE. A natural cavity, hollow space, or chamber in the earth, but with an opening to the surface. The term cavern means essentially the same thing, but is often used to imply largeness or indefinite extent. Most caves and caverns are the result of the removal of limestone in solution by underground water. See KARST PLAIN. (92, 66, 72)

CHIMNEY. See HEADLAND.

CIGAR-SHAPED MOUNTAIN. See SYNCLINE.

CINDER DOME. See VOLCANO.

CIRQUE. A deep, steep-walled amphitheater-like depression, roughly semi-circular in plan, cut into a slope by erosion beneath and around the head of a glacier. It occurs not only at the head of a

valley but also independently as a major indentation in an otherwise smooth slope, resulting from ice erosion.

The cirque depression is gradually enlarged as the eroded rock fragments are carried away by slowly moving snow and glacier ice. The term is applied to depressions no longer occupied by glaciers as well as those filled with ice and snow. Many cirques are deeper near their headwalls than in their outer parts, with the result that their rock floors are rock basins, some of them containing lakes.

The rugged nature of many high mountain summits is due to the development of cirques. An individual cirque can vary considerably in size - from a few hundred feet to a mile and more in diameter and several hundred feet deep.

In low mountain ranges, like the Big Horn Range of Wyoming, and in low-latitude ranges just within the limit of glaciation, only the uppermost parts of the valleys have been glaciated. The resulting cirques are small and the preglacial form of the mountain area is not greatly changed. A topography characterized by a rolling upland, out of which cirques have been cut like so many big bites, is known as biscuit-board topography. It represents an early stage, or only a partial completion, of the process of glaciation.

Several synonymous terms are as follows: corrie (Scotland), cwm (Wales), botn (Sweden), and Kar (Germany). (65, 92, 43)

CLAY DUNE. See DUNE.

CLIFF. See ESCARPMENT, SEA CLIFF.

COASTAL PLAIN. A level plain resulting from withdrawal of the sea from

a continental area. Coastal plains may be broad or narrow and may be the result of recent or ancient uplift. They are usually underlain by horizontal or gently dipping strata laid down in the ocean before its withdrawal. Subsequent subaerial erosion may have dissected the plain substantially, leaving relatively flat, broad interstream areas, broken by occasional low cuestas formed on upturned beds, as remnants of a continuous plain. (53, 92, 89, 4)

COL. A sharp edged gap with a smoothly curved profile that results when two cirques enlarging toward each other cut through the ridge that separates them. A col may result from the intersection of the wall of a cirque with that of a glacier trough. Many mountain passes have originated in this way. Perhaps ice overflows through the gap from one cirque to the cirque or glacial trough valley beyond, and the col is thus enlarged, lowered, and smoothed in outline to a U shape. They are sometimes called glacial cols. (43, 92)

COLLAPSE SINK. See SINKHOLE.

COLUMNAR STRUCTURE. The form of jointing in some dark colored igneous rocks which is in long, flat-sided prisms, frequently six-sided and more or less vertical. Although it is not a land form, it is useful in recognizing them. (4)

COMPOSITE SCARP. See ESCARPMENT.

COMPOSITE VOLCANO. See VOLCANO.

CONTINENTAL SHELF. See WAVE-CUT BENCH.

CORAL REEF. See REEF.

CORDILLERA. See MOUNTAIN.

COULEE. A short, blocky, steep-sided lava flow, generally of glassy rhyolite or obsidian (acidic lava), issuing from the flank of a volcanic dome or from the summit crater of a volcano where the rising lava has breached the walls and projected beyond as a short, stubby, tongue.

The term coulee is also applied throughout the northwestern states to any steep-sided gulch or water channel and at times even to a stream valley of considerable length. Perhaps the term lava coulee should be used for the first case and eroded coulee used for the second definition to eliminate confusion. (92, 18, 106)

COVE. See BAY.

CRATER. A steep-walled depression at the top of a volcanic cone or on the flanks of a volcano, directly above a pipe or vent that feeds the volcano, and out of which volcanic materials are ejected. In its simplest form, a crater is a flat-bottomed or pointed, inverted cone more or less circular in plan. Immediately after an eruption, the diameter of the bottom of the crater is seldom over 1000 feet. Subsequent landslides from the walls, however, may partially fill the bottom of the crater.

Craters are primarily due to explosions at the top of the pipe feeding the volcano. Fragmental rocks are blown into the air, and the largest material, landing within some hundreds of feet, build a circular wall.

Pit craters or volcanic sinks, typically exposed in the Hawaiian

Islands, are circular depressions with steep walls which have resulted mainly from collapse following lowering of the molten rocks or magma. Sometimes a crater forms within another to form what are called nested craters. Some craters are floored by solid lava; those that are occupied by a lake of lava are sometimes called lava pits. Maars, also called embryonic volcanoes, are flat-floored explosion craters that are either devoid of cones or have very small cones. There is little or no associated magmatic material because the cones consist largely or entirely of fragments of the country rock. See CALDERA. (92, 12, 4)

Other miscellaneous crater-like land forms are found although much less commonly. Bomb and mine craters are formed by man-made blasts and have the general characteristics of volcanic explosion craters, including the encircling rim of ejected material. Meteorite craters are produced by the impact and accompanying explosion of an object of extraterrestrial origin. (92)

CRATER LAKE. A lake, generally of fresh water, formed by the accumulation of rain, snow, and ground water in a volcanic crater or caldera with relatively impermeable floor and walls. A good example is Crater Lake, Oregon, although the lake actually occupies a larger depression known as a caldera. (4, 89)

CRESCENT BEACH. See BEACH.

CRETS. Steep, opposed inward facing escarpments of breached anticlines.

CREVASSE FILLING. A nearly level-topped ridge composed of water deposited glacial drift. Differing from an esker, it is short, straight,

and flat-topped and does not run in any particular direction. Crevasse fillings are generally associated with outwash or lake terraces and are deposited by glacial streams in an open crack at the surface of the ice. They are similar in cross section to an esker, however, ranging up to 150 feet and having steep sides. Kames are quite similar in origin and composition but are shorter and conical rather than ridge-like in form. See ESKER, KAME. (93)

CUESTA. A low ridge formed when erosion lays bare the outcrop of a very gently dipping resistant formation. A cuesta is generally limited to ridges with strata dipping at less than 20 degrees.

A cuesta naturally occupies a much larger area than does the ridge resulting from the baring of the outcrop of a more steeply dipping stratum. Its surface is a gently inclined dip slope which merges on the downward slope with the surface of the lowland developed on the overlying weak stratum, while upwards it is terminated by a sharp edge overlooking a steeper escarpment leading down to a lowland developed on the underlying weaker formation. (89, 12)

CUPOLA. See BATHOLITH.

CUSP. The point where two terraces intersect or the terminal points of barchan dunes. See also BEACH CUSPS.

CUSPATE BAR. See BAR.

DELTA. An alluvial deposit at the mouth of a river in a body of standing water, either the ocean or a lake, where the shore line is generally built forward and is often cut by distributaries of the main

stream. The name was first applied to such an area at the mouth of the Nile, which resembles the Greek letter delta.

A delta will be built only when more material is supplied than can be disposed of by wave action and tidal and other currents. Thus, deltas are more common in lakes than in the ocean, for in lakes there are no appreciable tides, and currents and wave action are in general weaker than in the ocean.

Although each delta has its own individual form as far as details are concerned, at least three forms are commonly encountered. The arcuate delta, relatively simple in outline, more or less fan-shaped or arcuate, convex toward the sea. A delta of this type, that of the Rhine being an example, is often built of coarse gravel, sand and silt. The river flowing over such a deposit tends to have a shallow, braided channel and an extremely intricate system of anastomosing currents. The digitate delta (or bird's foot) is built by streams carrying large amounts of extremely fine material, of which the Mississippi is an example. The outer border of such a delta exhibits the pattern of a bird's talons. The long narrow projections this figure implies are in actuality the natural levees, here the only parts of the deltaic deposit to project above the water surface. Estuarine deltas are formed by streams whose mouths have been and still are submerged. They deposit their loads in the form of long narrow estuarine filling which may constitute submerged river bars or extensive flood plain or marshy land area. (65, 92, 89)

DELTA LAKE. A water area enclosed within a delta. See DELTA.

DESERT PAVEMENT. A flat region in a desert (often alluvial or

lacustrine plains) that has had much or all of the finer material removed by the wind. There is a sorting of materials according to size with the coarser materials being left behind, forming a protective mosaic of closely-fitted gravel, pebbles, and boulders.

An extensive desert pavement, devoid of any fine material, is called a hamada, and is in marked contrast to the sand desert known as an erg. (4, 89)

DIGITATE DELTA. See DELTA.

DIKE. A tabular body of igneous rock that has been injected into and fills a fissure in older rock. The dike cuts across the structure of the older formations and therefore is discordant. Dikes occur in all types of material, igneous, metamorphic and sedimentary and vary from less than an inch to several miles in thickness, extending to many miles in length. These bodies commonly stand in more or less vertical positions, though many are inclined at lower angles. When the igneous rock of the dike is more resistant to erosion than the surrounding material, it may be left standing as a dike ridge. Conversely, a dike valley may result when the dike rock is weaker than that of its surroundings.

Radiating dikes are often found in groups around a common point, usually a central volcanic region, extending for long distances into the surrounding country. Ring dikes are oval or arcuate shaped in plan and are either vertical or steeply inclined. They are associated with faulting around volcanic centers, often encompassing down-faulted volcanic material.

The term igneous hogback has been used for those features described above as dike ridges. However, the term hogback should be limited to those ridges formed of tilted sedimentary rock. (12, 92, 4)

DISTRIBUTARY. A river branch that flows away from the main stream and does not rejoin it. They are most common in river deltas or on alluvial fans where they appear as abandoned channels. It is the opposite of tributary. (4)

DIVIDE. A dividing ridge or high ground between two watersheds. In mountainous areas it is a line that follows the highest points between adjacent watersheds, crossing peaks, ridges and passes.

DOAB. The low-lying tongue of land that lies between the confluence of two streams. (98)

DOLINE. See SINKHOLE.

DOMES. See ANTICLINE, SALT DOME.

DRAW. See VALLEY.

DROWNED VALLEY. A stream valley that has had its lower end flooded by the sea as a result of the coast subsiding or a rise in sea level. The portion of the drowned valley influenced by tidal action is often called an estuary (the Scottish term for a drowned valley is firth).

A drowned coast is the coastal area, as a whole, that has been depressed or has subsided so that the sea enters the lower ends of the valleys. See ESTUARY. (4, 92)

DRUMLIN. A streamlined oval hill composed principally of glacial till

which has its long axis parallel to the direction of glacial movement. Many, if not most, well-formed drumlins have a length which is several times the width. They have a longitudinal profile that is considerably steeper on the stoss end (direction from which the ice moved) than on the lee end. The sides are generally much steeper than the nose, often about 20 degrees. Drumlins are composed almost exclusively of till (boulder clay) but sometimes include lenselike masses of gravel and sand. They range in length from a few hundred feet to more than a mile, and in height from 25 to about 200 feet. Drumlins are rarely found singly but exist in great fields or swarms. Generally they display a striking parallelism of arrangement and double or triple drumlins may be found arranged en echelon. Drumlins characteristically lie several miles back of end moraines. They have been considered to be both erosional and depositional in origin, but most facts point toward deposition as till.

Some drumlins have bedrock cores, the till having been plastered down on an uneven rock floor. These rock drumlins grade into what have been called crag-and-tail forms. The latter consist of ice-smoothed knobs of solid rock which give way on the leeward side to tapered streamlined tails of till instead of terminating in plucked surfaces of rock-like typical roche moutonnees. (43, 92, 93, 42, 48)

DRY WASH. Same as ARROYO.

DUNE. A hill or ridge of wind-blown sand. A dune is formed wherever there is a source of dry sand and where winds are of sufficient strength to move the sand. In general, dunes are started by the presence of some obstruction, such as a plant or rock outcrop, in

the lee of which sand piles up. Also considered as a source of dunes are irregularities of the wind currents that cause sand to pile up in spots. Also there are places where rapidly disintegrating sandstones, in projecting masses, furnish a large volume of sand grains to the wind. Dunes are either the mobile or migrating type or they have become anchored or stabilized. Where dunes accumulate in a humid climate they are always more or less "fixed" by the growth of vegetation and such fixation may become complete, the vegetation becoming quite continuous and resulting in the formation of a layer of topsoil.

Several types of dunes or wind-blown deposits of sand similar to dunes are commonly recognized. A barchan dune (also spelled barchane and barkhan) is a small dune of crescentic ground plan with the horns of the crescent pointing in the direction toward which the dominant wind blows. Typical barchans have gentle windward and steeper leeward slopes. They are formed where the supply of sand is rather meager and where the average winds are moderately strong.

Longitudinal or seif dunes are long narrow ridges, parallel to the prevailing winds, wider and steeper sided on the windward side and tapering to a point on the leeward side. Seif chains have been described (Bagnold) that are 100 to 210 meters high and others which are 300 kilometers long. Their crests form knife-like ridges with many peaks and sags. One side of the crest may be rounded, and the other may show a collapse front (slip face) at right angles to the prevalent wind direction.

A transverse dune is a strongly asymmetrical dune ridge extending transverse to the direction of dominant sand-moving winds. The leeward slope stands at or near the angle of repose of sand, while

the windward slope is comparatively gentle.

A parabolic dune is a long, scoop-shaped hollow, or parabola, of sand with points tapering to windward (concave side toward the wind). The windward side is much more gentle in slope than the leeward side. The term is generally restricted to those dunes that approach the true form of a parabolic curve, while the more general U- and V-shaped "dunes of deflation" are termed upsiloidal dunes.

Whalebacks or sand levees are flat-topped sand ridges which extend parallel to the prevailing winds but lack the collapsing fronts which mark seifs. They also have much larger dimensions. A whaleback may be 100 miles long, 2 miles wide, and 150 feet high. They seem to be confined largely to the Egyptian Sand Sea. (92)

A sand sheet is a large sand area marked by extreme flatness, the only topographic relief being small ripples. The Selima sand sheet of the Libyan desert is an outstanding example, consisting of a few feet of sand resting on bedrock, and covering some 3000 square miles.

Other minor forms associated with dunes include a sand shadow which is an accumulation of sand to the lee of and in the shelter of an obstruction, such as a boulder, bush, or cliff, which interferes with stream-line air flow and checks the wind's velocity. When sand shadows form where wind sweeps sand over a cliff or escarpment they are sometimes called sandfalls. Sand drifts are found to the lee of a gap between two obstructions. This gap acts as a funnel through which sand trails out to the leeward.

Coastal dunes are found chiefly on low-lying land recently abandoned or built up by the sea or a lake. As a sea advances, the

waves throw abundant sand up on the beach. As the sea retreats, a succession of dune ridges may be built. But the sand may ascend cliffs, travel inland, and spread over the country so as to bury a former relief.

A clay dune is simply a dune made up of clay particles rather than sand. They are limited in extent and importance. They may develop on lacustrine plains that develop clay flakes upon drying. (92, 65, 9, 71, 4)

DUNE COMPLEX. A term often applied to the complete and overall topographic forms which make up the moving landscape as a whole, including the various types of dunes - accumulating, fixed, and in course of destruction - with sand plains and ponds, lakes and swamps caused by the blocking of streams. See DUNE. (92)

DUNE RIDGE. See DUNE.

END MORaine. See MORaine.

ERG. A very extensive area in a desert, generally to the leeward of playas and wind-scoured hollows which supply sand, covered by thick masses of sand with a surface that has the billowy form of dunes. Though extensive in area in great deserts like the Algerian Sahara, ergs are small as compared with the extent of the contrasting bare stony surfaced desert regions called hamadas and regs. (53, 92, 4)

EROSIONAL ESCARPMENT. See ESCARPMENT.

ESCARPMENT. A long cliff or steep slope facing in one general direction composed either of consolidated or unconsolidated material. The

abrupt change in elevation is usually produced by erosion or faulting or both. The abbreviated form scarp is commonly used for the term escarpment. A scarp may range from a few feet to thousands of feet high and vary considerably in slope, but is always considerably steeper than the surrounding region. Scarps are not necessarily indicative of faulting, because they may develop independently of faulting, being formed by subaerial erosion as along a cuesta, for example. Those scarps that have formed principally due to erosion may simply be termed erosional scarps. Cuesta scarps are common in areas of gently tilted rock while wave-cut escarpments often mark the positions of present and past shore lines. Sides of glacial troughs and stream-cut valleys are often scarp-like in character, but they are paired and therefore easily distinguished from fault scarps. Also, the fronts of lava flows and landslides may be locally scarp-like.

Scarps associated with faults are generally recognized as being of three types. A fault scarp is the term applied to an abrupt cliff or scarp produced directly by movement along the fault, even though erosion may have greatly changed the initial face. A fault-line scarp owes its relief to differential erosion along a fault line because there are rocks of varying resistance on the two sides of the fault line. A composite scarp is one that owes its height partly to differential erosion and partly to actual movement along the fault.

Scarpets, also called piedmont or alluvial scarps, are minor features that are indicative of active faulting. They lie at or along the base of mountains, often paralleling fault-block ridges. The height of these scarpets ranges from a few feet to a hundred

feet in some cases. They are usually found in the alluvium or unconsolidated material found in fans, aprons, terraces, etc. The existence of such scarps is positive evidence of recent faulting, for they could not persist long in these unconsolidated materials. (4, 12, 92, 89, 35, 51)

ESKER. A relatively long, narrow, sinuous ridge composed of water-laid glacial-fluvial drift. The longitudinal profile is also very irregular or sinuous and often contains gaps which separate segments of the esker. Most eskers extend parallel to the direction of glacial movement. They are considered to have been formed by streams of meltwater flowing off through crevasses and through tunnels in the bases of stagnant ice sheets. Some eskers extend uphill and across divides and drumlins, suggesting that these, at least, were let down onto the ground moraine and represent fillings in englacial or superglacial stream channels. These narrow, steep-sided ridges range up to 150 feet in height and their sides slope at approximately 30° , the angle of repose of the sand-gravel mixture of which they are composed. Their length varies considerably, but can be traced for tens of miles in some areas.

Eskers are most common on low, swampy plains. The ground on one or both sides of an esker may form a pronounced depression, termed an esker trough. An esker delta or outwash delta is sometimes formed where the stream which formed the esker terminated. Synonyms for esker are as follows: os, osar, asar, eschar, escar, eskar, serpent kame. (92, 43, 93, 42, 49)

ESKER DELTA. A relatively small delta formed at the terminal end of an

esker, where it emerges from underneath the glacier. It is usually fan-shaped and resembles the conventional arcuate delta. See DELTA, ESKER. (93, 92)

ESKER TROUGH. See ESKER.

ESTUARINE DELTA. See DELTA

ESTUARY. The widened channel at the mouth of a river, in which there is a marked tidal action. An estuary is usually formed by submergence, or "drowning" of the river valley, which then is subjected to the erosive action of waves and tides. See DROWNED VALLEY. (4)

EXFOLIATION DOME. A smooth dome-like hill or mountain formed by the large scale separation of gigantic concentric flakes (called exfoliation) of massive rock, generally of the granitic type. The domes are quite often bare of vegetation owing to the absence of soil development. The great domes of the Yosemite Valley in California and Stone Mountain Georgia are good examples. Another term that has been used for this feature is monolith, which comes from the fact that they are generally large masses of hard rock relatively free from joints, or rather, monolithic. (4, 101, 29)

FACETED SPUR. See TRIANGULAR FACET.

FAULT. A fracture or rupture in the materials of the earth's crust along which the opposite walls have moved past each other. A fault occurs when rocks are strained past the breaking point and yield along a crack or series of cracks so that corresponding points on the two sides are distinctly offset. Some faults are only a few

inches long, and the total displacement is measured in fractions of an inch. At the other extreme, there are faults that are hundreds of miles long with a displacement measured in miles and even tens of miles. The terms shear zone or fault zone are often applied to closely spaced subparallel structures along which there has been distributive movement. An overthrust fault is a spectacular feature along which large masses of rock are displaced great distances over an adjoining surface. See OUTLIER. (12)

FAULT-LINE SCARP. See ESCARPMENT

FAULT SCARP. See ESCARPMENT.

FENSTER. See INLIER.

FINGER LAKE. See GLACIAL TROUGH.

FIRTH. See DROWNED VALLEY.

FJORD. See GLACIAL TROUGH.

FLATIRON. A triangular-shaped ridge composed of tilted rock layers carved by streams crossing a hogback ridge. The top is usually pointed and the base is broad where it dips below the surface. Flatirons typically occur in series along the flanks of domal mountains and quite often consist of resistant sedimentary beds of sandstone. (89, 4)

FLOODPLAIN. A low, flat plain bordering a flowing stream and containing deposits of alluvium as a relatively smooth strip along the bottom of a valley. Generally the flood plain is considered to be only that

part of the bordering lowland which is flooded nearly every year.

Floodplain scrolls often appear along streams as crescent-shaped or slightly sinuous strips of coarse alluvium along the convex banks of stream meanders. They are subject to repeated reworking as the stream cuts laterally and downward in the process of attaining a profile of equilibrium. The term bottom land has been used somewhat locally to mean flood plain. See ALLUVIAL PLAIN. (92, 89, 4, 70)

FLUTINGS. Streamlined shapes of glacial origin, either ridges or grooves or both. The negative elements, or grooves, range from simple striations on rock surfaces to glacial grooves in soft rock up to 100 feet deep and a mile long. Another similar feature that is not in rock is a fluted till plain. The positive elements, or ridges, include drumlins and rock drumlins. (92)

FLUVIAL PLAIN. A plain produced by the action of running water. It is composed of the smaller land forms of fluvial origin such as alluvial plains and floodplains, combined to form the overall feature of a fluvial plain. The materials are generally considered to be continental outwash, as is the Great Plains, a good example. (4, 89, 92)

FOOTHILL. One of the lower subsidiary hills at the foot of a mountain or of higher hills. Generally used in the plural if used at all. (4)

FRINGING REEF. A reef that grows directly against the bedrock of a coast and actually constitutes its shore line. Along island and continental coasts that meet the environmental requirements (see REEF), reef-building corals and algae will first establish colonies at the ebb-tide shore line. Their growth and spread along the coast and

outwards, coincidentally, in time give rise to a fringing reef. The continuity of such a fringing reef is interrupted only where large streams from the land either induce too much turbidity or reduce too much the salinity of the ocean waters for growth of the reef-building organisms. (29, 53, 104)

FUMEROLE. See HOT SPRING.

GAP. A short valley or opening across a ridge. A water gap is a pass across a ridge in which a stream flows from one side to the other. Contrasted to this, a wind gap is a similar feature that has been abandoned by the stream and exists as a pass. (4, 89)

GASH SINK. See LOESS PLAIN.

GASSI PLAIN. A sand-free surface between dunes or groups of dunes. (4, 89)

GEYSER. See HOT SPRING.

GEYSER CONE. See HOT SPRING.

GLACIAL TROUGH. A stream-cut mountain valley which has been altered by alpine glacial erosion so that it has a characteristic U-shaped cross section. Topographically it is very distinctive with smooth valley walls and is rather irregular and ungraded in the long profile. A glacial trough heads at the lower edge of a cirque threshold, the conspicuous drop to the floor of the trough is called a trough head-wall. Often the descent of a trough floor takes place in a series of glacially carved steps. When these steps develop with a reverse

slope, a rock basin or series of basins may form a chain of lakes called paternoster lakes.

Where large glacial troughs are fed by tributary glaciers, the latter usually comes in well above the main valley floor. After the ice of both valleys melts, the tributary valleys hang high above the main trough, forming the picturesque hanging valleys which often give rise to beautiful waterfalls.

A fjord (or fiord) is a deep, narrow, and steep-walled inlet of the sea formed in the same way as a glacial trough. Actually, it is a glacial trough occupied by sea water either as the result of subsequent subsidence after glaciation or, as in most cases, is the result of glacial action by tongues of ice which actually entered the ocean. In the same class with fjords, but differing from them in that they are above sea level, are numerous trough lakes or, where several trough lakes lie parallel to each other, forming what may locally be called finger lakes. (43, 92, 57, 106, 89)

GORGE. See VALLEY.

GRABEN. See BLOCK MOUNTAIN.

GROUND MORaine. See MORaine.

GULCH. See VALLEY.

GULF. A relatively large portion of the sea more or less enclosed by land. A gulf is relatively larger than a bay and also a gulf generally is indented into the land further in proportion to its width than is a bay. See BAY. (4, 81)

GULLY. See VALLEY.

HAMMADA. See DESERT PAVEMENT.

HAMMOCK. See HUMMOCK.

HAYSTACK. See PEPINO HILLS.

HEADLAND. A high point or projection of land into the sea that is a more resistant portion of a differentially eroding sea cliff. Headlands subjected to wave erosion from two sides may result in sea arches or sea caves. When portions of the headland are completely detached, the remnants are known by such names as sea stacks, chimneys, skerries, or simply islands. These isolated remnants often become weirdly shaped due to the wave action and bedding planes or joints of varying attitude.

A blowhole is formed where part of the roof of a deeply penetrating sea cave falls in, leaving an open funnel, up through which a blast of air and spray is projected as each wave enters the mouth of the cave. (4, 92)

HEADLAND BEACH. See BEACH.

HOGBACK. A sharp-created ridge that develops where the sedimentary rock dips are steep, roughly in excess of 45 degrees. (See CUESTA and HOMOCCLINAL RIDGE). Hogbacks have limited area, although they may have considerable length. Although the front slope or the bedding surface of a hogback may be slightly steeper than the backslope or erosional cross section of the formation, there is not the marked difference in the two that there is in a cuesta. Furthermore,

hogbacks remain rather well fixed in position. A slight shifting may take place as the landscape is lowered, but it is likely to be a matter of feet rather than miles, as may happen with cuesta scarps.

Such features as dike ridges should not be called hogbacks, even though they may resemble them in appearance, for they are features developed upon igneous intrusions rather than upon steeply dipping stratified rocks. (4, 92, 89)

HOMOCLINAL RIDGE. A mountain ridge developed upon the dipping beds on the flank of an anticline or syncline. The term homocline, from the Greek meaning "one inclination", may be applied to strata that dip in one direction at a uniform angle. Although many homoclines are, if large areas are considered, limbs of folds, the term is useful to refer to the structure within the limits of a small area. In older literature, these features were commonly called monoclines.

Homoclinal ridges develop in areas of moderately dipping strata, and there is a notable difference in the steepness as well as in the length of the front and back slopes. A homoclinal ridge is not so sharply defined as is a hogback nor does it have the areal extent of a cuesta. Although a hogback is a homoclinal ridge, there does seem to be a need for a term which describes those intermediate forms between hogbacks and cuestas which are found in so many areas. Strike ridge can be used synonymously with homoclinal ridge.

Limits separating the terms cuesta, homoclinal ridge, and hogback can be established according to the dip of their beds as follows: For a cuesta, less than 20 degrees; a homoclinal ridge, 20 degrees to 45 degrees; and for a hogback, greater than 45 degrees. (12, 92)

HOMOCLINAL VALLEY. A valley that has been eroded into a belt of weak rock between resistant beds on the flank of an anticline or syncline. Frequently homoclinal valleys are not so conspicuous as either anticlinal or synclinal valleys because they are likely to be minor rather than major drainage lines. Strike valley is synonymous with homoclinal valley. (12, 92)

HOOK. See BAR.

HORN. A pyramidal mountain peak with several facets, each facet being the headwall of a cirque, sculptured when three or more cirques erode headward toward a single high part of the mountain crest. These peaks standing above jagged crests are the dominating features of mountain ranges sculptured by alpine glaciers.

Well known examples of horns are the Matterhorn (horns are often called matterhorns) and Weisshorn in the Alps. Somewhat related in origin to horns but detached from the main mountain range are monuments or tinds, as they are called in Scandanavia. (92, 43, 106)

HORST. See BLOCK MOUNTAIN.

HOT SPRING. A thermal spring whose water has a higher temperature than that of its surroundings - generally considered to be above that of the human body (98°F). A geyser is a special type of hot spring that throws forth intermittent jets of hot water and steam. The action results from the contact of ground water with rock or vapor hot enough to generate steam under conditions that prevent circulation. The steam becomes superheated and periodically throws out the overlying water column. In rising toward the surface the hot water and

and steam dissolve quantities of mineral substance from the rocks they pass through. Much of this mineral substance is deposited in the form of geyser cones as the siliceous mineral geyserite around the hot springs and mouths of geysers.

A fumerole is a hole in the rocks from which steam and other gases (but no water) escape under pressure. They often occur in connection with geysers. A solfatara is a volcano in its late stages that has waned to the emission of steam and sulphurous gases from points within the crater. (106, 92, 4)

HUMMOCK. A small rounded or conical hill or knoll that rises out of lower ground. Simply a topographic term with no particular significance geomorphically, or genetically as with kame. It is spelled hammock in the southern states, especially Florida. (4)

INFILTRATION BASIN. A small dish-shaped depression where surface water collects and percolates into the ground. These basins are generally located on porous granular material, often on river terraces.

INLET. A short, narrow waterway connecting a bay, lagoon, or similar body of water with a large parent body of water. An arm of the sea (or other body of water), that is long compared to its width, and that may extend a considerable distance inland. (4)

INLIER. An outcrop of rock surrounded on all sides by geologically younger deposits. An inlier differs from an outlier in not necessarily being an isolated mass of rock, but merely an isolated outcrop which underground may be continuous with large masses of similar rock. An inlier may be caused by erosion of the crest of an

anticline, by erosion on the upthrown side of a fault, or by partial burial of isolated hills on an old erosion surface. A special case of the inlier is the fenster, or window. In this case, an erosional break through, an overthrust sheet or through a large recumbent anticline exposes younger rocks underneath. (69, 92, 12)

INSELBERG. A small mountain or hill standing above a surrounding level plain. The term means "island mountain" and could be understood to refer to any isolated peak. See MONADNOCK. (4, 69)

INTERLOBATE MORaine. See MORaine.

ISLAND. A body of land completely surrounded by water at the mean high water stage. Small islands are often termed isles or islets.

ISTHMUS. A narrow strip of land, bordered on both sides by water, that connects two larger bodies of land. Sometimes called a neck.

JOINT. A fracture or parting plane that divides rocks, along which there has been no visible movement parallel to the plane or fracture. Most joints are developed along planes, although some have curved surfaces. They may be due either to shearing under compression or to tearing apart under tension, however, most joints are due to contraction upon drying or cooling or due to release of confining loads as in granites. Joints may have any attitude; vertical to horizontal or at various inclinations in between. They differ greatly in size, ranging from a few feet to several thousand feet in both the direction of strike and dip. Joints never occur alone - the interval between them may be a few inches to several hundred feet. A group of more or

less parallel joints is called a joint set. A joint system is made up of two or more joint sets to give a characteristic pattern such as radiating, concentric, etc. (12, 4)

KAME. A rounded to conical-shaped hill or irregular mound composed of water deposited glacial drift. The material is usually semi-stratified to unstratified sands and gravels. Most kames are considered to be ice-contact features whose materials were laid down in contact with an ice surface. Kames originate in at least two ways. Some are bodies of sediment deposited in crevasses and other openings in or on the surface of stagnant or nearly stagnant ice which later melted away, leaving the accumulated sediment in the form of isolated or semi-isolated mounds. Another type of kame consists of small deltas or fans (see **ESKER**) built outward from ice, or inward against ice, which later melted, collapsing and isolating the mass of sediment to form an irregular mound.

Kame terraces are fillings or partial fillings of depressions between a stagnant glacier and the sides of its trough. These depressions are called fosses, and owe their existence to the more rapid rate of melting which takes place here because of the added effect of heat absorbed or reflected from the valley sides. After the ice has melted, the stratified drift is left as a constructional terrace. The significant distinction between kame terraces and ordinary stream terraces is that they are not the remnants of former valley fills and were never much more extensive than now. The surfaces of most kame terraces are irregular, but because of their depositional origin some may be flat and have a down-valley slope,

much like a valley train terrace, and may even merge down-valley into a valley train. Most kame terraces are rather short and discontinuous. See VALLEY TRAIN. (43, 25, 42, 41, 55, 57)

KARST PLAIN. A region of nearly horizontal or gently-dipping limestone strata that contains literally thousands of sinkholes and acts as a sieve, the sinkholes acting as drains which convey surface waters to underground routes. Such an area is underlain by caves and/or caverns. (92, 67, 72)

KETTLE. A basin or cavity in glacial drift, created by the melting of a former mass of glacier ice that was wholly or partly buried in the drift. Most kettles are less than a mile in greatest diameter and less than 25 feet deep. They may be irregular in plan, but most of them tend to be circular. (43)

Kettles occur in stratified drift and less commonly in till. Steepness of the sides of kettles and number of kettles is related to the coarseness of the material, being greatest in coarse gravels. The steep sideslopes are caused by sliding and creeping of the sediment as its ice support was removed.

Kettles occur singly, as groups (for example in a pitted outwash plain), or in complex arrangements where they occur as a maze of mounds and basins often called a kettle-kame moraine. In many localities a considerable part of the kettles of outwash plains are long and narrow and are arranged in rows called kettle chains, which may mark preglacial or interglacial valleys in which ice blocks persisted. When a kettle is filled with water, it is commonly called a kettle lake. (12, 92, 69, 4)

KETTLE-KAME MORaine. See MORaine.

KLIPPE. See OUTLIER.

LACUSTRINE PLAIN. An extremely flat area that once was the site of a lake that has since become extinct. Lakes are short-lived, and many of the smaller and shallower glacial lakes have already disappeared. Their sites are now marked by lacustrine plains or areas of mucky soils or bogs, if not quite extinct, and these are often termed muck plains.

The small lacustrine plains which are often found in glacial mountain valleys are often striking because their flatness contrasts sharply with their surroundings. Shore lines of the larger extinct lakes are marked by beaches, bars, and sand dunes. Lacustrine plains are generally underlain by clays and silts, which may display well developed lamination or varves. However, some are underlain by sands, and commonly grade from sands and gravels near the shore to finer material at the center. Alkali flats and playas are particular types of lacustrine plains. (4, 92)

LAGOON. In general, the expanse of quiet water between a reef and the shore. The reef can be either a barrier reef or an atoll. Probably better known are the lagoons surrounded by an atoll. Atoll reefs have the form of walls in that the descent from the level of the reef into the water is abrupt on both sides. Oceanward the steep slopes go down to the deep sea bottom. On the inner side the declivities are no less steep but terminate shortly on the lagoon floor. The lagoon floors, almost without exception, are flat across

their full width so that the water over them is everywhere of nearly uniform depth. Although different lagoons are not of the same depth, the maximum is approximately 300 feet. See REEF. (92, 53, 4)

LAHAR. A torrential flow or flood of water-saturated volcanic debris down the slopes of a volcano in response to gravitative force. Lahars are a type of landslide and result when pyroclastic materials resting on the flanks of a volcano become saturated with water (through the action of heavy rains, the escape of water from a crater lake, or the melting of snow) and move downslope as a slide or flow. The term mud flow is synonymous. (4)

LANDSLIDE. Downward and outward movement of slope-forming materials - natural rock, soils, artificial fills, or combinations of these materials. The moving mass may proceed by any one of three principal types of movement: falling, sliding, or flowing, or by their combinations. Many classifications have been proposed for earth movements, based on several factors. One such classification is shown in Table 2

A fall includes both soil fall and rock fall and is a mass in motion that travels most of the distance through the air. It includes free fall, movement by leaps and bounds and rolling of rock and debris fragments without much interaction of one fragment with another.

A slide is movement caused by finite shear failure along one or several surfaces which are visible or whose presence may reasonably be inferred. As seen from the chart, two subgroups of slides may be distinguished according to the mechanics of movement - those in which the moving mass is not greatly deformed, and those which are greatly deformed or consist of many small units. A slump is perhaps the

TABLE 2. A CLASSIFICATION OF LANDSLIDES

TYPE OF MOVEMENT	TYPE OF MATERIAL			
	BED ROCK		SOILS	
<u>FALLS</u>	<u>ROCK FALL</u>		<u>SOIL FALL</u>	
few units	rotational	planar	planar	rotational
<u>SLIDES</u>	<u>SLUMP</u>	<u>BLOCK GLIDE</u>	<u>BLOCK GLIDE</u>	<u>BLOCK SLUMP</u>
many units		<u>ROCK SLIDE</u>	<u>DEBRIS SLIDE</u>	<u>FAILURE BY LATERAL SPREADING</u>
<u>FLOWS</u>	ALL UNCONSOLIDATED			
	ROCK FRAGMENTS	SAND OR SILT	MIXED	MOSTLY PLASTIC
	<u>ROCK FRAGMENT FLOW</u>	<u>SAND RUN</u>	<u>LOESS FLOW</u>	
		<u>RAPID EARTH FLOW</u>	<u>DEBRIS AVALANCHE</u>	<u>SLOW EARTH FLOW</u>
	wet	<u>SAND OR SILT FLOW</u>	<u>DEBRIS FLOW</u>	<u>MUD FLOW</u>
<u>SOLIFLUCTION</u>	Very wet slow moving mixture			
<u>CREEP</u>	<u>ROCK CREEP</u>	<u>TALUS CREEP</u>	<u>ROCK-GLACIER CREEP</u>	<u>SOIL CREEP</u>
<u>COMPLEX</u>	Combinations of materials or type movement			

Modified after Sharp (1938)
and HRB Special Report 29 (1958)

most common type of slide. It usually takes place as an intermittent movement of earth or rock masses along a curved, "spoon-shaped" surface as kind of a superficial faulting and leaves an amphitheater-shaped scar. Typically, slump involves a backward rotation of the mass, as a result of which the surface of the slumped mass often exhibits a reversed slope. Frequently slumping takes place as several small independent units; the result is that the surface of the slumped mass has a number of step-like "terraces".

In a flow, the movement within the displaced mass is such that the form taken by the moving material or the apparent distribution of velocities and displacements resembles those of viscous fluids. Slip surfaces within the moving mass are usually not visible or are short-lived, and the boundary between moving and stationary material may be sharp or it may be a zone of plastic flow. As indicated on the chart, there is a considerable range of material involved as well as moisture content.

Mudflows are perhaps the most common type of flow. They move rapidly enough to be perceptible to the eye, have a higher water content than earthflows, and are usually confined to channels. Favoring their formation are: (1) unconsolidated materials at the surface which will become slippery when wet; (2) steep slopes; (3) an abundant but intermittent supply of water; (4) sparse vegetation.

Mudflows are characteristic of the drier regions because in such areas the vegetation is sparse and the infrequent rains are often torrential. Mudflows commonly follow the channel cut by streamflood across alluvial fans at the bases of mountains. They consist largely of mud but may transport boulders weighing many tons. The edges of

mudflows may be marked by sharp linear ridges called mudflow levees.
See LAHAR.

Solifluction is another type of slow movement that is generally confined to high-latitude and high-altitude areas. There are four conditions which promote solifluction: (1) good supply of water; (2) moderate to steep slope relatively free of vegetation; (3) permanently frozen ground beneath surface; and (4) rapid rock weathering. Solifluction differs from mudflow in that: it is slower and more continuous movement; it is not confined to a channel as a mudflow usually is; and it develops under severe subarctic or alpine climates rather than under arid or semi-arid climates as do mudflows. The topographic effects of solifluction are usually not striking because it operates over the whole surface rather than being concentrated in channels. Locally it may result in terrace-like forms upon slopes or the filling of smaller basins.

Creep is the slow movement downslope of soil and rock debris which is usually not perceptible except through extended observation. Four general types have been recognized: soil creep, talus creep, rock-glacier creep, and rock creep. The effects of soil creep are usually not particularly apparent except upon vegetation and man-made structures. It is made evident through such features as curved trees and tilted fence posts and telephone poles.

An avalanche is a large mass of accumulated snow or snow and ice that falls from a mountain slope into the valley below, often acquiring more snow on its descent to the bottom. Avalanches move so rapidly that they are catastrophic in nature, often causing great damage. Although the avalanche itself is not a landform the scar

it leaves is an erosional landform, and is called an avalanche scar or track.

Complex landslides, as the name implies, are a combination of the types of movements. Many landslides are complex, although one type of movement generally dominates over the others. (2, 85, 99)

LATERAL MORaine. See MORaine.

LAVA BLISTER. See TUMULUS.

LAVA COULEE. See COULEE.

LAVA PIT. See CRATER.

LAVA PLAIN. A broad term descriptive of a comparatively flat, smooth and level area that is underlain by a relatively thin succession of lava flows resulting from the product of fissure eruption. The flatness of the plain's surface is largely determined by the horizontal attitude of the underlying flows. Restrictive terms are basalt plain, etc. (92, 4, 29, 66)

LAVA PLATEAU. A tableland or flat-topped area of considerable extent elevated above surrounding country on at least one side and underlain by a thick succession of lava flows, most of which are basalts and the product of fissure eruption. (92, 4, 29, 66)

LAVA TUNNEL. See TUMULUS.

LINEAMENT. Any topographically controlled line on the earth's surface. They may be produced by faults, joints, bedding, and foliation.

LOESS PLAIN. A deposit of loess over lowlands or areas of low relief that is thick enough to sufficiently obscure the underlying topography and form a new plain surface. These loess plains frequently display characteristic short deep gullies and a right-angular or pinnate drainage system.

Loess sinks or loess wells are features of loess plains that usually occur near the rims of gullies, ravines, and canyons and are due to the settling of the soil consequent upon the mechanical removal of underlying material, rather than from its removal by chemical action as in limestone sinkholes. Another term sometimes used is gash sink. (4, 16, 92)

LOESS RIDGE. A deposit of loess that is in the form of low, elongate ridges. The parallel ridges are generally considered to be shaped by wind. Loess ridges 30 to 100 feet high and having a nucleus of glacial drift, wind-blown sand, or rock have been given the name pahae. (4, 16, 92)

LOESS SINK. See **LOESS PLAIN**.

LONGITUDINAL DUNE. See DUNE.

MAARS. See **CRATER**.

MALPAIS. An area of very rough surface composed of lava flows. See **SCABLAND**. (98)

MARINE-BUILT TERRACE. See **WAVE-CUT BENCH**.

MARINE-CUT TERRACE. See **WAVE-CUT BENCH**.

MARSH. See SWAMP.

MASSIF. See BLOCK MOUNTAIN.

MATTERHORN. See HORN.

MEANDER. One of a series of somewhat regular and looplike bends in the course of a stream, developed when the stream is flowing at grade, through lateral shifting of its course. As the process of lateral erosion progresses, the strip of land (meander spur) between the upstream and downstream parts of the meander diminishes in width to a narrow meander neck. If the stream succeeds in cutting through the neck, a meander cutoff is formed. The abandoned route is called a meander scar if it no longer contains water, and an oxbow lake if its ends have been blocked and it is filled with water.

Incised meanders or inclosed meanders are cut down into rock as a result of regional uplift of an area (called rejuvenation). The uplift results in the stream increasing its grade, and it begins down-cutting once again, the stream continuing to flow in its meandering channel.

A natural bridge will sometimes be formed when incised meanders being to erode laterally and a meander neck is cut through leaving a portion of the bedrock bridged over the top. Natural bridges may also form in karst areas. (92, 4, 65)

MESA. A Spanish word meaning table, the term is applied to isolated tablelands capped with a protective covering (called the rimrock) which is essentially horizontal in attitude. Features similar in character but with more limited summits are usually called buttes.

Some mesas owe their existence to the protective cover of sedimentary rocks, particularly sandstones, but others may be capped with lava flows or gravels and boulders. Mesas and buttes vary greatly in size and in height above the surrounding areas. A mesa has a summit area of at least one-tenth of a square mile. They are generally considered to be erosional remnants left by streams which have worn away the land around them. Commonly a mesa is rimmed by a scarp formed by the resistant cap rock, but the term has also been loosely applied to any broad, flat surface of moderate elevation which is bounded on at least one side by a descending cliff. These features, especially the larger ones, which are not completely isolated may be better described as plateaus.

METEORITE CRATER. See CRATER.

MONADNOCK. An isolated high point, often a group of hills or even subdued mountains, which, because of greater resistance to erosion or some other cause, remains projecting above the general level of an almost level plain or peneplain. These remnants, or residuals, of a former relief get their name from the prominent example, Mount Monadnock, in New Hampshire. See BORNHART, INSELBERG. (4, 92, 89, 53)

MONOLITH. See EXPOLIATION DOME.

MORaine. An accumulation of glacial drift having a topographic form that was constructed directly by the ice, but having no relationship to the underlying surface. A moraine is of considerable lateral extent and does not include minor features such as drumlins. Two

general types of moraine are recognized: ground moraine and ridge moraine.

Ground moraine constitutes the accumulation of drift beneath the glacier and forms a surface of low relief which is lacking any linear, ridge-like features. The surface is generally flat (often called a till plain) to gently undulating and the drift may be thick enough to obliterate any topographic expression underlying it, however in many cases, the moraine exists as a thin veneer over bedrock surfaces.

A ridge moraine is an all-inclusive term that is used to designate any ridge-like morainic form as differentiated from ground moraine. The material in ridge moraines is deposited in three ways, by lodgement, pushing, or dumping. The topographic expression varies considerably, those ridge moraines composed chiefly of coarse material often stand higher than those composed of clayey material. Also, ridge moraines are seldom continuous for great distances, but usually are segmented because of breaks made through them by drainage outlets or lack of material deposited in some places. Often the surface of a ridge moraine composed of more granular material is made up of hills and basins containing lakes or swamps. This knob and basin topography has been given the term kettle-kame moraine.

Ridge moraines are generally subdivided into several types depending upon their relative position to the ice lobe. A terminal moraine (or end moraine) is a ridge moraine built along the downstream or terminal margin of a valley glacier or along the margin of an ice sheet. Interlobate moraines form a reentrant at the junction of two ice lobes. Many ridge moraines have been classed as recessional moraines because of their positions back of terminal or

end moraines.

Associated with alpine glaciation, a lateral moraine is built along the lateral margin of a glacier occupying a valley. A medial moraine is produced when the two lateral moraines merge beyond the point at which two valley glaciers coalesce to form a larger glacier. This long mound of material extending lengthwise on the surface of the glacier may be left as a ridge on the surface of the valley floor when the glacier melts, but more than likely it is obliterated during the recession of the glacier up the valley. (4, 89, 92, 43, 65)

MORASS. See SWAMP.

MUCK PLAIN. An extremely flat area, of somewhat limited extent, that was once the site of a former lake that has since almost become extinct. Muck plains are underlain by wet, spongy deposits of muck and peat. See LACUSTRINE PLAIN.

MUD VOLCANO. See VOLCANO.

MUSKEG. See SWAMP.

NAPPE. See OUTLIER.

NATURAL BRIDGE. See MEANDER.

NATURAL LEVEES. Low but distinct alluvial ridges that parallel a river course. They are highest near the river and slope gradually away from it. They may be a mile or more in width, and they owe their greater height near the stream channel to the cumulative effect of

sudden loss in transporting power when a river overflows its banks. They cause the present meander belt of a river to stand up above the floodplain as a low alluvial ridge. Natural levees marking former river positions may be present on a flood plain, although usually in fragmentary state. (89, 92, 65, 4)

NEEDLE. See MESA.

NESTED CRATERS. See CRATER.

NUNATAK. An isolated hill or peak which is surrounded by ice, as in the Antarctic Ice Sheet. Although perhaps incorrectly, it has been used to denote a hill or peak which was formerly surrounded, but not over-ridden by glacial ice.

OFFSHORE BAR. See BAR.

OUTLIER. An isolated mass of rock surrounded on all sides by outcrops of older (geologically) rocks (a stratigraphic outlier). Outliers may be of the nature of isolated remnants or cappings of hills separated from a main cliff by erosion, they may be due to the planation of synclines leaving remnants of younger rocks in the centers or they may be due to erosion leaving younger remnants on the down-thrown sides of faults. In this latter case, when the outlier is a large body of rock that has moved forward more than a mile from its original position, either by overthrusting or by recumbant folding, it is termed a nappe outlier, (a structural outlier), or simply nappe. In contrast to the nappe is the klippe, an isolated block of rocks separated from the underlying rocks by a fault, but older than

those underneath. (12, 92, 4)

OUTWASH DELTA. See ESKER.

OUTWASH PLAIN. A plain of low relief composed of glacial outwash material. It is usually produced by the merging of a series of outwash fans or aprons much in the same way as do alluvial fans or aprons. As the term implies it is formed beyond the glacier itself. Those built into non-glaciated areas or areas not recently glaciated are usually unpitted. Their surface may exhibit shallow depressions or infiltration basins produced by melting of small ice blocks incorporated in the outwash or by deflation before establishment of vegetation upon the outwash plain. However, most outwash plains as observed today have an extreme smoothness which is due to later reworking of deposits of sand and silt by wind action. Outwash plains vary from narrow fillings in the bottoms of pre-existing valleys to coalescing outwash fans which bury the entire country for many miles.

Pitted Outwash Plains are found where ice blocks have been buried beneath outwash. The ice subsequently melts, resulting subsidence of overlying material to form kettles. Extreme pitting generally indicates that outwash sands and gravels were laid down over a nearly continuous mass of stagnant ice. A pitted outwash plain differs from other types of topography with which it may be confused, such as kettle-kame moraines and hummocky ridge moraines, in that its material is better sorted and its surface is that of a more level plain than that displayed by ridge moraines. (43, 29, 4)

OXBOW LAKE. A meander scar or channel that has been abandoned by a meander cutoff and has filled with water. The lake is crescent-shaped like an oxbow and dammed or plugged at each end by alluvial silts and clays. (2, 89)

PALISADE. See **SILL.**

PARABOLIC DUNE. See **DUNE.**

PASS. A gap, defile, or other relatively low break in a mountain ridge. The term comes from the fact that it is a natural passageway for a trail, road, etc. Typical passes may be cols, water gaps, or wind gaps. (98)

PATERNOSTER LAKES. See **GLACIAL TROUGH.**

PATTERNED GROUND. A group term for the more or less symmetrical forms such as circles, polygons, steps, ice segregations, and stripes that form distinct patterns on the surface of the ground. They are found particularly in regions of severe frost action although not confined to them. (4)

PEAK. The more or less conical summit of a mountain or hill. One of the crests of a mountain, or, if isolated, the entire hill or mountain. (98)

PEDESTAL ROCK. A cap or boulder of more resistant rock supported by pillars or pedestals of weaker rock or unconsolidated material. They have been explained by wind abrasion but it is doubtful whether this process has contributed significantly to their shaping. They are more commonly the result of differential weathering aided by rainwash.

Also called mushroom rocks. (92)

PEDIMENT. See ALLUVIAL APRON.

PENEPLAIN. A land surface worn down by erosion to a nearly level or broadly undulating plain. It is not generally agreed on the concepts of the manner of formation of a peneplain. Some authorities maintain that it must be eroded by streams, while others include all destructive processes. The term "peneplane" has been suggested because the area has been planed down. However, it is argued that the word "plane" suggests a geometrical surface, which the peneplain is not, thus divorcing the term from its physiographic connotation. In general, the term peneplain can be applied to the old land surfaces which were formerly reduced almost to base level and subsequently raised bodily to a higher level, and which may or may not have been again dissected by streams. Where dissected the old peneplain surface is represented by remaining flat hilltops. Where no flat remnants of a peneplain actually survive, accordance of summit levels may indicate that a peneplain has been destroyed by erosion, a number of peaks still reaching to about the same level. (92)

PENINSULA. A body of land nearly surrounded by water and connected with a larger body by a neck or isthmus.

PEPINO HILLS. Rounded, conical-shaped hills that remain during an advanced stage of solutional destruction of a limestone plain. They are erosional remnants somewhat analogous to monadnocks, but are formed in a tropical environment. Several other names are used to denote these unusual features including haystacks, hums (Yugoslavia),

mogotes (Cuba), buttes temoines (France) and cockpits. They exist singly or in groups and range in height from 25 to 300 feet. They are typically asymmetrical and often are full of caverns and lesser solutional openings. (4, 92, 72)

PIEDMONT PLAIN. See ALLUVIAL APRON.

PIEDMONT SCARP. See ESCARPMENT.

PIEDMONT SLOPE. See ALLUVIAL APRON.

PINGO. A hill or mountain completely covered by an ice sheet caused by release of ground water under hydrostatic pressure. (4)

PINNACLE. See MESA.

PIT CRATER. See CRATER.

PITTED OUTWASH PLAIN. See OUTWASH PLAIN.

PLAYA. A level or nearly level plain that occupies the lowest part of a completely closed desert basin (see BOLSON) and that is covered with water at irregular intervals for ranging lengths of time. Most playas are dry except after the occasional desert shower, when they are termed playa lakes. Their surfaces are often covered with glistening salts which have been precipitated from the ephemeral lakes which exist on them. See ALKALI FLAT. (4, 65, 92)

PLUG DOME. An extruded mass of andesitic or rhyolitic lava so viscous that it does not flow or spread but forms a cylindrical or conical plug in the crater of a volcano or causes doming of the rocks above.

Care should be taken not to confuse a plug dome with the volcanic plug formed when lava in the conduit of a volcano solidifies and which after extinction of the volcano may be exposed by erosion as a volcanic neck. A plug dome is formed by the active protrusion of lava in and above the crater of the volcano, not by erosion. See VOLCANIC NECK. (92, 12, 27)

PLUTON. A body of non-tabular intrusive igneous rock of any size or shape. Used in this general sense, the term may seem to be of little value, but applies well to situations where data is insufficient to allow use of a more specific term. See BATHOLITH, BOSS and STOCK. (12)

POCKET BEACH. See BEACH.

POLJE. See SINKHOLE.

POTHOLE. A more or less circular hole in the rocky bed of a stream, usually at the foot of a waterfall. They are formed by the grinding action of gravel and sand being swirled around by eddy currents. (1, 4)

PRAIRIE. An extensive treeless and grassy plain. Also called savannah, steppe, llanos, and pampas in other countries, but mean essentially the same thing.

PRESSURE RIDGE. See TUMULUS.

RAVINE. See VALLEY.

RECESSIONAL MORaine. See MORaine.

REEF. A topographic ridge or mound of rock in the sea which is partially or almost wholly covered by water. More specifically, the term refers to a coral reef, as they are commonly called.

Reef-building corals live in tropical seas where the waters have a temperature of 68° F. or higher. For their vigorous growth the water must also be free of sediment and be of normal marine salinity. They flourish at depths from 15 feet down to 120 feet below the surface. Generally, 200 feet is the depth limit for growth of reef-building corals, with 300 feet as a maximum. The little animals thrive best at sites where waves and currents are active. Such environmental circumstances are available at their optima in the open seas and along the east coasts of the continents.

Actually, what is commonly called a coral reef was not built solely by corals. Numerous other organisms contribute to the growth of a reef, among them being numerous forms of lime secreting calcareous algae, hydroids, stromatoporoids, and the shells of echinoderms, brachiopods, foraminifera and mollusca. The term bioherm (organic mound) is a more appropriate name for such structures, but they have been called reefs so long that the name persists despite its inadequacy. Colonial corals and calcareous algae to a large degree build the superstructure, but the voids between are filled with the skeletons of other organisms as well as organic and inorganic debris.

Three main types of reefs are recognized. See BARRIER REEF, FRINGING REEF, and ATOLL. (53, 92, 104)

REEF RING. See ATOLL.

RIDGE MORaine. See MORaine.

RIFT VALLEY. See BLOCK MOUNTAIN.

RIMROCK. See MESA.

RILL. A small channel or streamlet formed by running water. As a stream is traced headward, the branches decrease in size and their erosive power decreases to the point where only these small rills exist. They are most noticeable at the heads of gullies that terminate in cultivated fields, where the natural cover has been removed and erosion has begun to etch out a miniature stream pattern. (4, 89)

RING DIKE. See DIKE.

RIVER BAR. See BAR.

RIVER TERRACE. A steplike bench along a river valley, elevated above the reach of high water and above the flood plain. Most terraces along rivers are remnants of valley bottoms or flood plains formed when the land was lower or stream higher or when the valley carried a larger stream, during glacial melting, for instance. (4, 26, 92)

ROCHE MOUTONNEE. A knob-shaped mass of relatively resistant rock which has been shaped by scouring and plucking of glacial ice. The stoss side or side against which the ice moved is typically striated and grooved, gently inclined and often even polished. In sharp contrast to the stoss side, the lee end is steep and has a ragged, quarried surface due both to plucking and the jointing of the rock itself. The term comes from a fancied resemblance of their forms to fleeces

of gigantic sheep. (43, 92, 4)

ROCK DRUMLIN. See DRUMLIN.

ROCK GLACIER. An accumulation of broken rock fragments which moves slowly but perceptibly downhill under its own weight and by the aid of interstitial ice. Also called a rock stream, this feature has been reported thus far only from glaciated terrain near the firm limit. (43) It has a remarkably glacierlike form characteristically lobate, with a maximum dimension of nearly one mile. It covers gentle slopes and horizontal surfaces, all of which are situated at the bases of cliffs, especially those facing away from the sun. See TALUS. (92, 43)

ROOF PENDANT. See BATHOLITH.

SADDLE. A low point in the crestline of a ridge. Similar to PASS.

SALINA PLAIN. See ALKALI FLAT.

SALT DOME. A small domal structure resulting from the upward movement of a central core of rock salt. The core of salt domes has pierced the adjacent sedimentary rocks. A typical salt dome is an anticlinal structure that may vary in shape from sharp ridge-like flexures to shallow and flat circular domes. The salt core may or may not have a massive cap of anhydrite, gypsum, limestone, or dolomite. Topographically salt domes may be either positive or negative, but more commonly they stand up from a few feet to a hundred feet or more above their surroundings. (12, 92)

SAND DRIFT. See DUNE.

SANDFALL. See DUNE.

SAND LEVEE. See DUNE.

SAND SHADOW. See DUNE.

SAND SHEET. See DUNE.

SANDWASH. A sand or gravel streambed, devoid of vegetation and containing water only during sudden heavy rainstorms. Same as ARROYO.

SCABLAND. A basalt plain or plateau area where denudation has removed or prevented soil development and exposed the underlying bare rock. The term originated in the Pacific Northwest and is applied to the great scars which mar the face of the basaltic plateau of eastern Washington and break it up into a maze of buttes, mesas, and canyons. The area is generally considered to have been produced by glacial meltwaters. Although this is the classic example, any similar "scabby" basalt plain or plateau can appropriately be called scabland. In the Southwest the equivalent term is malpais. (4, 89, 92, 18)

SCARP. See ESCARPMENT.

SCARPLET. See ESCARPMENT.

SEA ARCH. See HEADLAND.

SEA CAVE. See HEADLAND.

SEA CLIFF. A general term referring to the seaward limit of a coast

that is marked by a nick or scarp resulting from the erosional forces of wave action. (4, 92)

SEA STACK. See HEADLAND.

SEIF DUNE. See DUNE.

SHEAR ZONE. See FAULT.

SHIELD. A broad and normally somewhat convex area with low to moderate relief that is composed of very old rocks. It is an area that has persisted as a land mass through much of the geologic past. Such a history implies composition of ancient igneous and metamorphic rocks and maintenance of the areas at above sea-level altitudes of considerable height through most of the time of their existence. These elevations appear to have been renewed from time to time as broad upwarplings. (4, 89, 92)

SHIELD VOLCANO. See VOLCANO.

SHINGLE BEACH. See BEACH.

SHOAL. A shallow place in a body of water, generally a lake or sea. It is a body of unconsolidated material such as a bar that is always submerged, although not deeply.

SHORE. The zone extending from the low-tide to the landward limit of effective wave action. The term shore line has been used synonymously with shore, however, a technical distinction can be made. A shore line marks the position of the water level at a given time and varies between the low-tide shore line and the high-tide shore line

positions. Shore line also is a line delimiting the water level of a lake.

SILL. A tabular body of igneous rock that has been injected while molten between beds of sedimentary or igneous rocks or along the foliation planes of metamorphic rocks. Sometimes called a sheet, the sill is younger than the rock on either side of it and can be horizontal, vertical, or inclined, as long as it is parallel to the bedding or schistosity of the adjacent rock. Sills have relatively great lateral extent as compared with their thickness, ranging from a foot to several hundred feet in thickness and may cover an area many miles in extent. A sill valley or sill ridge may result where the sill is vertical or tilted and outcrops at the surface of the ground. Generally the igneous rock composing the sill is more resistant to erosion than the enclosing strata so that a ridge is left standing above its surroundings. In the case of a horizontal sill, a cliff may result in valley walls due to differential erosion, and where this cliff shows picturesque columnar structure it is often termed a palisade. Often parts of the horizontal sills are isolated from the surrounding country and form flat-topped mesas or buttes which may or may not be covered by remnants of the rocks into which the magma was intruded. See DIKE. (12, 92)

SINKHOLE. A surface depression in a region of limestone, created by solutioning of underground channels and subsequent collapse of the surface. Topographically, a sinkhole is a depression that varies in depth from a mere indentation of a few feet to a maximum of about 100 feet. Most of them vary in depth from 10 to 30 feet. In area,

they range from a few square yards to an acre or more. The most common form is a funnel-shaped depression broadly open upward, but there are many variations from this.

Various terms have been used to denote differences in form or type of sinkholes. A Doline is developed slowly downward by solution beneath a soil mantle without physical disturbance of the rock in which it is being formed. Collapse sink is applied to sinkholes that exhibit steep-sided, rocky, and abruptly descending forms, resulting from collapse of the roof over an underground solutional opening. Surface water sometimes enters sinkholes through surface openings called swallow holes.

Dolines may become clogged with inwashed clay and hold water to form a sinkhole pond or karst lake. A special type of collapse sinkhole is the karst window. It is an unroofed portion of an underground stream course through which may be seen a stream which flows out of a cavern at one side, across an open space, and into a cavern at the opposite side. Some large karst windows have been given the term uvala.

Another special sinkhole is the polje. It is an elongated basin with a flat floor and steep enclosing walls which owes its existence to solutional modification of downfaulted or downfolded limestone blocks. A typical polje is a sizeable feature covering many square miles, whereas an uvala commonly covers only a few acres. A cenote is another term for sinkhole (Yucatan). (92, 67, 72, 4)

SKERRY. See HEADLAND.

SLOUGH. A depression that is continuously or intermittently filled with

water, often filled with mud or muck. The term is used for a variety of features such as an abandoned stream channel, a bottom-land creek, a swamp, a bayou, etc. Sometimes spelled slue. (92, 4)

SLUMP. See LANDSLIDE.

SOLFATARA. See HOT SPRING.

SOLUTION VALLEY. A large depression or short, blocky valley formed by solutioning of limestone. It was originally drained entirely by surface drainage and represents a transitional stage between surface drainage and underground drainage. A solution valley is recognized by its highly variable width, by its originating in steep-walled sinkholes, by natural bridges that may still span the valley, and by tributary valleys left hanging above through having lost their water to subsurface drainage. Also called a karst valley, it is not typical of a karst plain, but rather is completely or nearly enclosed by clastic rocks. (92)

SPATTER CONE. A miniature steep-sided volcanic cone formed where gas or fire fountaining has thrown out liquid clots of lava. They sometimes attain heights sufficient to be called volcanic cones, although they seldom are more than 50 feet high. (92, 29, 27)

SPINE. See NEEDLE.

SPIT. See BAR.

SPUR. A subordinate ridge of a mountain that extends itself from the crest into the valley.

SQUEEZE-UP. See TUMULUS.

STEPPE. See PRAIRIE.

STEPTOE. A hill or "island" of bedrock (often granite) surrounded by a lava flow or lava plain. (4)

STOCK. A mass of intrusive igneous rock, very similar to a batholith, but the surface is exposed over an area of less than 40 square miles. A stock may be a protrusion from an underlying batholith not yet exposed, or it may be an independent intrusion. The term has often been used synonymously with boss. See BATHOLITH, PLUTON. (12, 92)

STORM BEACH. See BEACH.

STRAND. Same as BEACH.

STRATO-VOLCANO. See VOLCANO.

STRIKE RIDGE. The subsequent ridge or divide which separates strike valleys. The term strike refers to the direction of a line formed by the intersection of the bedding plane with a horizontal plane. The strike is at right angles to the dip. (89) See HOMOCLINAL RIDGE, HOGBACK.

STRIKE VALLEY. A subsequent valley that is guided by the outcrops of the weaker members of a series of tilted stratified rocks running parallel with the strike. See HOMOCLINAL VALLEY.

SWAMP. A tract of wet, spongy land that may or may not be covered with

water. Swamps develop in depressions that are not deep enough to form lakes, about the shallow margins of bodies of water that are invaded by plant growth, and under climatic conditions of high relative humidity and much and often-repeated rainfall. Many swamps support a growth of various reeds and grasses; others are covered with alders, or large trees, as the mangrove and cypress of the south and the tamarack of the north. Many extensive swamps are covered with moss.

Swamp is a general term and others have been used to denote various types of swamps. Marine swamps, as the name implies, are associated with the sea and are usually covered with rushes, reeds and salt grasses. These treeless swamps may be called marshes, salt marshes or coastal marshes, and where they are alternately covered and uncovered by tides they are known as tidal marshes or flats. A swamp composed chiefly of decaying vegetation matter or peat is often called a bog or peat bog. Bog is an Irish term, while its equivalent in Scotland is morass. (4, 89, 92, 98)

Organic terrain is a term assigned to ground which has a significant thickness of defunct vegetative matter and includes not only this vegetative matter but also the immediate mineral sublayers, the living vegetative cover, and certain micro-relief features. The term is used interchangeably with muskeg. A classification of this material has been suggested by Radforth (77a).

SYNCLINAL RIDGE. A mountain ridge developed by erosion upon the down-folded beds of a syncline that are more resistant than adjoining beds. They are due entirely to erosion and may not be very

extensive. Synclinal ridges drop off abruptly by escarpments to the bordering valleys on either side.

A syncline is a fold that is concave upward, or, in more complicated folds, is inferred to have had such an attitude at some stage in its development. The word is from the Greek, meaning "together inclined," and refers to the fact that in the simplest synclines, the two limbs dip toward each other. But the limbs may dip in the same direction, be horizontal, or be complexly folded. A syncline is a fold with younger rocks toward the center of curvature. (12)

As with anticlines, the axis or crest is sometimes horizontal and sometimes plunging. In the same way as with anticlines, the outcrops of a plunging syncline tend to converge, but in a broader, "cigar shaped" pattern. A doubly-plunging syncline reverses its direction of plunge to form an elongated structural basin (See BASIN). A structural basin may be circular in plan and therefore not show any distinct trend. (12, 92)

SYNCLINAL VALLEY. A valley due to the initial synclinal folds of a region. Like anticlinal ridges, however, which may be due to the stripping off of overlying strata, so also may synclinal valleys be formed by removal of the higher beds from a syncline. (12, 92)

TABLE MOUNTAIN. A mountain having a comparatively flat summit and one or more precipitous sides. Same as MESAS or BUTTE.

TALUS CONE (or TALUS SLOPE). An accumulated heap of rock fragments derived from and lying at the base of a cliff or very steep slope. The fragments may be large or small and the aggregate heap usually

has a form determined by gravity and the angle of repose of the material involved. The term should not be used for any loose, fragmental rock lying on a slope but is restricted to occurrences where there is a projecting mass, or cliff from which the fragments were obviously derived. The term scree is used in Great Britain, whereas talus is more commonly used in the United States.

The loose debris on steep talus slopes sometimes assumes a sort of flowing motion and descends the slope with the similar form and rate of a glacier. Such bodies of moving debris are termed talus glaciers. See ROCK GLACIER. (4, 89, 65)

TARN. A small mountain lake that occupies the ice-scoured basin floor of a cirque.

TEPEE BUTTE. A butte eroded from a hard formation, generally sandstone or limestone, that is overlying softer shale. The shale erodes to form a sloping pedestal resembling an Indian tepee.

TERMINAL MORaine. See MORaine.

TERRACE. A plain of limited extent which has a descending face on one side and a face ascending to the adjacent land on the other side. It commonly is a narrow strip and borders a river, lake, or the sea. Accordingly, the term terrace should be used with modifying terms that denote its method of origin, such as alluvial, marine, fluvio-glacial, etc. Many streams and lakes are bordered by a series of terraces at different levels, indicating former water levels. Portions of a valley flat that are slightly higher than, but parallel to the floodplain and no longer receiving sediments are often called

fossil flood plains. However, where distinctly elevated and higher in elevation they might form terraces. See FLOODPLAIN, WAVE-CUT BENCH, KAME TERRACE, VALLEY TRAIN, RIVER TERRACE. (4, 89, 92, 26)

TILL PLAIN. A level or gently undulating land surface composed of glacial till resulting from regional deposition by ice, where complete burial of preglacial topography has taken place. This ice-contact surface is often quite flat and in some of the midwestern areas the average thickness of drift exceeds 100 feet and locally over preglacial valleys it may be several hundred feet thick. In general, where the glacially deposited surface lacks conspicuous ridge-like form, it may be called ground moraine. (43, 92, 4)

TOMBOLO. See BAR.

TRANSVERSE DUNE. See DUNE.

TRIANGULAR FACET. The truncated end of a spur or ridge that ends with a broad base and apex pointing upward. It originated through the cutting away of the lower terminations of these ridges by faulting, glaciation or wave action.

Also called truncated or faceted spurs, they are often formed in glacial troughs by abrasion when the ice stream tends to straighten the original valley course. (4, 92, 43)

TROUGH LAKE. See GLACIAL TROUGH.

TUFF RING. See VOLCANO.

TUMULUS. A bulging low dome-like hill on the surface of a lava flow

with cracks in the crest through which lava may have been extruded. Tumuli do not seem to be gas blisters but rather are domings of the lava crust produced by the resistance which the lava surface has offered to the spreading of more fluid lava below and are thus much like laccoliths in origin.

Other minor topographic features of similar origin are associated with lava flows. Squeeze-ups are small mounds or ridges of lava on the surface of a flow produced by the extrusion of viscous lava through an opening in the solidified crust. Linear squeeze-ups result from the rise of viscous lava into fissures and ordinarily they project from a few inches to a foot or two above the surface. Pressure ridges are somewhat similar in appearance but develop on a larger scale. They are generally considered to be the result of lateral pressure originating from viscous drag of slowly moving sub-crustal lava. Lava blisters are small, hollow, steep-sided swellings raised on the surface of some pahoehoe lava flows and formed by gas bubbles puffing up the viscous crust of the flow. Lava tunnels and lava caves, which are common in basaltic lava fields, result from the draining out of lava from beneath the solidified crust. They have reached widths and heights of 100 feet or more and lengths of several miles. Tunnels are exposed by later collapse of part of the roof, or by the cutting of valleys across the flow. (12, 29, 4, 92, 27)

TUNDRA. A treeless plain characteristic of arctic regions. The thin soil layer is dark colored and mucky, and overlies permanently frozen subsoil (permafrost). The typical vegetation consists of

mosses and lichens.

UPSILOIDAL DUNE. See DUNE.

VALLEY TRAIN. A long narrow body of glacial outwash sand and gravel confined within a valley. It usually heads at an end moraine (ridge moraine) and extends down-valley from it. Except for those still in the process of formation, they are likely to be marked by terraces above present valley floors. While active deposition is in progress, the valley trains have braided stream patterns. A valley train which has been reduced to a terrace or pair of terraces on opposite sides of a valley by the present stream often resembles a kame terrace. Kame terraces can be distinguished from valley train terraces by the poorer degree of assortment of their materials and by the fact that indentations in their fronts, which mark the ice-contacts surface, bear no relationship in size to cusps which a stream would develop in cutting out a valley train. See KAME.

Major drainage lines or sluiceways carrying meltwater and outwash material developed valley trains extending many miles into unglaciated areas. As the ice receded the valley trains were extended headward as long as the sluiceways continued to receive meltwater. Thus, some valley trains are several hundred miles long.
(92, 89, 4, 43)

VOLCANIC NECK. A column of igneous rock formed by solidification of lava or the consolidation of volcanic breccia in the vent or pipe of a volcano. When the volcano has been deeply eroded, the rock which solidified in the throat often stands above its surroundings as a

great spire because it is more resistant than the stratified material of the walls of the volcano. Very often this neck is the only remaining evidence of former volcanic action in a region. Care should be taken to not confuse a volcanic neck with a plug dome which is an extrusion of highly viscous acidic lava. The central conduit that supplies the magma in active volcanoes is often called a neck, pipe, plug, or vent. See PLUG DOME. (4, 29, 12, 92)

VOLCANIC SINK. See CRATER.

VOLCANO. An opening in the earth from which molten rocks and other material are expelled. If the material accumulates around the vent it will build up a cone which may reach the proportions of a large mountain. This cone may also be called a volcano. Several methods of classifying volcanoes have been used. One system is based largely upon whether the volcanic pile was built up as the result of the outpouring of fluid or effusive lavas, as the product chiefly of ejected pyroclastic materials, or by a combination of the two.

A central vent is the essential feature of a volcano, and the cone or dome associated with it is incidental as far as the history of the volcano is concerned. The shape and profile of the accumulated debris around the central vent are to a large degree influenced by the type of eruption. The angle of repose of the fluid or solid materials which are emitted from the central vent largely determine the steepness of a volcano's slopes.

Shield volcanoes or basalt domes from where fluid basaltic lava is extruded, and, although they may attain great height they may have such broad bases that they are not best described as cones. A

vast number of flows each a few feet thick contribute to their growth. The lava sheets are nearly always parallel to the dome-shaped surface - that is, nearly horizontal under the broad summit and steeper on the flanks. In the case of high domes, lava often pours out from fissures on the flanks instead of at the summit. The lava breaks through, apparently, as a result of the enormous hydrostatic pressure in the lava column reaching to so great a height.

Basalt cones have been regarded as embryonic domes. They are rare and are likely to be low rather than high cones because of the fluidity of basaltic lava. Widely spreading basalt floods pour generally from localized vents, which may be somewhat enlarged parts of fissures or systems of rifts, and over the vents arise the low broad lava hills of flatly conical shape. Though quiet outpouring is the ruling method of basalt eruption, quite frequently mounds of scoria are built over vents - often termed scoria mounds.

Ash or cinder cones are built where eruptions are of the explosive type with a predominance of pyroclastic materials. Growth of a cinder cone begins around a crater with an encircling ring of pyroclastic debris consisting of ash, lapilli and coarser materials. This is called a tuff ring, particularly when composed largely of the finer-sized materials. True ash or cinder cones seldom attain heights in excess of 1000 feet. A cinder cone in which lava has broken through the sides and carried away the broken materials is called a breached cone.

A composite volcano or strato-volcano is a mountain constructed of exploded rock fragments and of lava flows which have come mainly from the central vent. It exhibits rough stratification produced

by alternating sheets of lava and pyroclastic material. Its structure attests to alternating periods of explosive and quiet eruption. In general, a composite volcano is a steeply sloping, conical mountain, with a crater in its top. The slope of the sides of the mountain is slightly concave upward, with gentler gradients near the base and steeper toward the top; the slope near the top may be as great as 30 degrees. Many composite volcanoes rise 10,000 feet or more above their bases.

A mud volcano is a small cone-shaped mound built of ductile, plastic clay and ordinarily formed by the eruption of sulfurous and bituminous mud from a central vent or orifice. A few mud volcanoes have reached a height of about 250 feet. The mud is formed from volcanic rock decomposed by hot acid water and ground to an unpalpable paste by the constant stirring due to uprise of steam through the mud. (4, 12, 27, 66, 89, 92)

WADI. See ARROYO.

WALLOW. A shallow depression suggesting a place where animals have wallowed (locally called "buffalo wallows"). They are believed to be the result of solutioning and subsequent settlement. (4, 98)

WASH. A dry stream bed. Also called dry wash. Same as SANDWASH, ARROYO.

WATER GAP. See GAP.

WATERSHED. The area drained by a stream and its tributaries that contributes water to a particular river, lake, or basin. Sometimes

referred to as the height of land from which the natural drainage flows in opposite directions, however, the term divide is more appropriate and is preferred.

WAVE-CUT BENCH. A level bench extending seaward from the base of a sea cliff produced by wave erosion. The bench is generally bare rock which has been worn quite smooth, although it may be covered by a thin, temporary deposit of sand, gravel, and pebbles. On the seaward side, the wave-cut bench grades into a nearly horizontal surface called an abrasion platform. This abrasion platform was formed under water as the result of long-continued abrasion by waves and currents. There is no sharp demarcation between the wave-cut bench and the abrasion platform, and where the two exist together, they are called a marine-cut terrace. Occasionally the abrasion platform may be missing and the wave-cut bench will terminate abruptly.

A marine-built terrace (or wave-built terrace, or built platform) is a graded surface beyond the marine-cut terrace that consists of the materials removed in the cutting of the marine-cut terrace. This terrace may extend for many miles seaward and together with the abrasion platform is commonly called the continental shelf. (92, 4, 89)

WHALEBACK. See DUNE.

WIND GAP. See GAP.

WINGED HEADLAND. See BAR.

WINDOW. See INLIER.

YARDANG. Probably the chief features sculptured by wind abrasion in desert regions are round or flat bottomed troughs separated by rounded, long, weirdly undercut or sharp crested ridges or by flat-topped mesas. The ridges and mesas stand from a few inches to more than 25 feet above the bottoms of the troughs. Yardangs and troughs are carved only into weak rock or rock mantle. (92, 53)

CLASSIFICATION AND GLOSSARY OF PARENT MATERIALS

Parent material, as used in this report, is considered to be the relatively unaltered earth material beneath the solum from which soil is formed. It is the nucleus of the land form. This definition brings up many questions that must be answered to define more precisely the term parent material.

Parent material as defined, excludes that part of the pedologic soil profile called the solum. In mature soils, the solum includes the layered systems at the surface which are commonly called the "A" and "B" horizons; the character of the solum material may be greatly unlike that of the parent material.

Parent material is not the synonym of soil. Soil has been variously defined by geologists, soil scientists, and engineers. Each has a definition of the term "soil" that is appropriate to his own particular interests. For instance, the soils engineer includes every type of earthen material from the rubbish of a man-made fill to a partially cemented rock as soil (23). To the pedologist, soil is a natural part of the earth's surface, being characterized by layers somewhat parallel to the surface resulting from modification of parent materials by physical, chemical, and biological processes operating under varying conditions during varying periods of time. The five major factors which condition the development of soil are: climate, topography, vegetation, time, and parent material.

The term parent material as used in this context includes both the consolidated "rock" and the unconsolidated "mantle" portions of the material beneath the soil horizons. In geological terminology the distinction is made between a rock and the incoherent material from which the rock is derived; for example, gravel is the name given to a certain loose material, but if a gravel has been converted during its later geologic history into a coherent mass, it is given a rock name and called conglomerate. Similarly, till is the name applied to a loose glacial material, but if a till has been changed to a coherent mass, that change is recognized by giving the resultant product the rock name, tillite. (78)

In a general sense, the term rock refers to any hard, solid matter derived from and forming an essential part of the earth. Such a general definition is not adequate for most purposes, however. Geologists and engineers are perhaps the most concerned about its proper usage -- both of their viewpoints should be considered.

In a strictly geological sense a rock is any naturally formed aggregate or mass of mineral matter. There are two prominent exceptions, however; coal which is largely of organic materials that are not minerals, and the natural glasses which were cooled from lava so fast that no minerals formed. A few rocks are made up of a single mineral, as, a very pure limestone. Usually two or more minerals are mixed together to form a rock. (58)

To the engineer, the term rock signifies firm and coherent material or unconsolidated substances that cannot normally be excavated by manual methods alone. As used in the field of soil mechanics, rock is distinguished from unconsolidated materials, or "soil", by the fact that it

will not disintegrate within a short period of time when immersed in water. (64) On the other hand, shale is considered by most engineers and geologists to be a reasonably hard, firm rock, but many varieties will disintegrate readily when immersed in water.

It thus appears that the general use of the word rock is far from being adequate for most uses without qualifying terms. The term is much too vague, for instance, when used to classify material for excavation unless rigorously qualified.

Geologic rock terms can give a very comprehensive insight as to composition and general nature of the consolidated portion of the earth's crust. They are used and discussed in this glossary under their three major divisions: igneous, sedimentary, and metamorphic rocks. These are explained in the following paragraphs and in Table 3.

Igneous rocks are formed by cooling or solidification of hot fluid rock material or magma. Plutonic rocks are those formed and cooled at great depths and are crystalline throughout. Volcanic rocks are those which have poured out on the earth's surface in the liquid state or have been blown as fragments into the air. Igneous rocks comprise the bulk of the earth's crust. They occur in bodies with a variety of shapes such as flows, dikes, sills, and batholiths. In a general way the igneous rocks are classified by the degree to which they have crystallized and by the kinds of minerals of which they are composed. Microscopic examination or chemical analysis may be necessary for detailed classification, and hundreds of different varieties of a dozen or so main types have been named.

Sedimentary rocks are formed by the accumulation of sediment in water or from air. They are formed through the agency of water, wind,

glacial ice, or organisms and are deposited at the surface of the earth at ordinary temperatures. The sediment may consist of rock fragments or particles of various sizes (conglomerate, sandstone, shale); of the remains or products of animals or plants (certain limestones and coal); of the products of chemical action or of evaporation (salt, gypsum, etc.); or of mixtures of these materials. Some sedimentary deposits (tuffs) are composed of fragments blown from volcanoes and deposited on land or in water. A characteristic feature of sedimentary deposits is a layered structure known as bedding or stratification. Each layer is a bed or stratum and lie flat or nearly flat when deposited.

The term sedimentary rock generally connotes some degree of coherence or consolidation. Some sediments are consolidated soon after deposition; other deposits may exist for millions of years in the unconsolidated state, and there are all gradations and degrees of consolidation. The aggregate changes occurring between deposition and lithification are termed diagenesis. During diagenesis, coherence is developed by compaction and dehydration, cementation, and recrystallization; one of these may be dominant, but commonly all three are concurrently at work. (75, 58, 91)

Metamorphic rocks are formed from original igneous or sedimentary rocks through alterations produced by pressure, heat, or the infiltration of other materials at depths below the surface zones of weathering and cementation. Rocks that have undergone only slight changes are not usually considered to be metamorphic; for practical purposes the term is best applied to rocks in which transformation has been almost complete or at least has produced characteristics that are more prominent than those of the original rock. Metamorphic rocks are more or less

TABLE 3. CLASSIFICATION OF ROCKS

Igneous Rocks						
Texture	← Light (acidic) Color Dark (basic) →					
	Essential Minerals					
	Quartz, Orthoclase	Orthoclase	Quartz, Plagioclase	Plagioclase	Plagioclase	Olivine
Plutonic	Very Coarse Grained	Pegmatite	Syenite Pegmatite	Quartz Diorite Pegmatite	Diorite Pegmatite	Gabbro Pegmatite
	Coarse to Medium Grained	Granite	Syenite	Granodiorite; Quartz Diorite	Diorite	Gabbro Peridotite
	Fine Grained	Aplite			Diabase	
	Medium to Fine Grained	Felsite			Basalt	
Volcanic	Glassy	Obsidian; Pumice				

Sedimentary Rocks				
Clastic (Physical Deposition)				
Texture (Grain Size)	Unconsolidated Sediment	Rock (Consolidated)		
		Conglomerate		
		Breccia; Fanglomerate		
Coarse Grained	Gravel	Tillite		
	Detritus; Rubble	Sandstone; Arkose, Graywacke		
	Till	Tuff		
Medium Grained	Sand	Siltstone		
	Volcanic Ash	Mudstone		
	Silt	Claystone		
Fine Grained	Clay, Silt, Sand	Shale		
	Clay			
Non-Clastic (Chemical Deposition)				
Type	Organic	Inorganic		
Carbonate	Limestone: chalk coquina coral	Limestone: calcareous tufa, calichi, marl, travertine		
	Dolomite	Dolomite		
Siliceous	Diatomaceous earth	Siliceous Sinter (Geyserite) Chert (Flint, Jasper)		
Carbonaceous	Coal: anthracite bituminous lignite Peat Muck			
Evaporite		Anhydrite rock Gypsum rock Rock salt		

Metamorphic Rocks				
Original Rock	Rock Produced by Contact Metamorphism	Rock Produced by Dynamic Metamorphism		
		Slate; Phyllite	Mica Schist	Gneiss
Shale	Hornfels			
Sandstone	Quartzite			
Limestone	Marble			
Dark (basic) Igneous	Serpentine (Greenstone)	Phyllite	Green Schist	Gneiss
Light (acidic) Igneous	(Altered Granites, etc.)	Phyllite	Mica Schist	Gneiss

reconstructed in place while remaining essentially solid. New minerals and textures come into being which are stable under the conditions that produce the change. Through metamorphism marble is produced from limestone, and dolomite, quartzite from sandstone, and phyllites, schists, and gneisses from other types of rocks. (58, 76)

Texture is a characteristic of natural earth materials that can be readily utilized in a classification. Considering rock textures, there are many that have explicit meanings; such as, granular, porphyritic, ophitic, trachytic, and fluidal. However, for the purposes of this report, rock textures have been divided into the more simple terms. Considering all rock types, these are: coarse, medium, and fine grained; dense, and glassy.

Considering the unconsolidated portion of the parent material, textures are based principally upon the following size classes:* boulders, greater than 6 inches in diameter; cobbles, 3 inches to 6 inches; gravel, 2 mm. to 3 inches; sand, 0.074 mm. (no. 200 U.S. Standard sieve) to 2 mm.; silt and clay, less than 0.074 mm.; and those defined specifically as "clay size", less than 0.002 mm. The sand size and larger is usually considered coarse textured, and silts and clays are fine textured. (8, 20, 23, 64)

Although a classification table has been possible for each of the rock divisions, such is not the case for the unconsolidated materials.

*Various agencies have classified these materials according to grain size, but there is incomplete agreement upon the size limits of each group. The limits presented here are in general acceptance, with the exception of clay. Most agencies classify "clay size" minerals as being less than 0.005 mm. in diameter, but the U.S. Department of Agriculture classification of less than 0.002 is becoming more widely recognized.

These materials can readily be subdivided as to texture, but specific names for each type of deposit are not sufficiently abundant for adequate classification as is true with the rocks. Specific origins of these unconsolidated materials can be suggested, however; these are: alluvial, colluvial, eolian, glacial, lacustrine, littoral, marine, and cumulose.

1. Alluvial deposits consist of those laid down by running water. The material is given the general name, alluvium, and includes gravel, sand, silt, and clay, and all variations and mixtures of these.

2. Colluvial deposits consist of earth material that has moved or been deposited mainly through the action of gravity. The general term colluvium includes talus and the material of landslides.

3. Eolian deposits are those materials whose constituents have been carried and laid down by the wind. The particle size of these deposits is limited to a narrow range, the most common deposits being dune sand and loess.

4. Glacial deposits, or as is more commonly used, glacial drift includes all material deposited either directly or indirectly by glacial ice. Glacial till, stratified drift, outwash, and erratics are all types of glacial drift.

5. Lacustrine deposits are those materials deposited in a lake environment. These include principally sand, silt, clay and the evaporites, such as alkali.

6. Littoral deposits are those laid down along the shore of a lake or the sea, generally between the limits of high and low tides, and under the influence of wave action.

7. Marine deposits are those laid down in the sea, usually beyond

the seaward edge of the littoral belt.

8. Cumulose deposits are those accumulations of dead plant and animal remains that have formed in place with relatively little detrital sediment. The two most common cumulose deposits are peat and muck.

It is suggested that these origins, in combination with the predominant parent material texture, be used when describing the parent material of land forms. For example, the land form esker might be interpreted as consisting of coarse-textured glacial drift.

A glossary of parent material terms, both rock and unconsolidated material is presented in the following pages. The writer suggests that further work be done in this area so that a complete, logical, and practical parent material classification can be formulated. Since adequate terms do not now exist, especially for unconsolidated material, perhaps new terms should be suggested.

GLOSSARY OF PARENT MATERIALS

AA. The Hawaiian term for solidified lava characterized by an exceedingly rough, jagged, or spinose surface. Most of the surface is covered with a layer of loose fragmental clinkery material a few inches to several feet thick. Below the surface the clinker fragments may be stuck firmly together. Aa surfaces are extremely difficult to traverse on foot and are impassable to vehicles. Although a sequence of aa flows may contain considerable amounts of interbedded, relatively loose, clinkery material, the large open cavities characteristic of pahoehoe are uncommon. See also PAHOEHOE and BLOCK LAVA. (58, 76, 4)

ACIDIC ROCK. An igneous rock composed of minerals which have a high proportion of silica (SiO_2). Granite, syenite and rhyolite are examples. Such rocks are usually light in color--some shade of gray, pink, or red.

ADOBE. A general term widely used in the southwestern United States and in Mexico for clayey and silty material that can be made into sun-dried bricks. Adobe tends to fracture into cubical blocks on moderate drying. It is widely distributed both on bedrock and on alluvium, and may be on slopes as well as valley floors. It may or may not be calcareous. The agent of deposition is apparently water.

ALLUVIUM. A general term for all detrital material deposited

permanently or in transit by streams. It includes gravel, sand, silt, and clay, and all variations and mixtures of these. It is usually applied to the deposits of streams in their channels and over their floodplains and deltas. The term alluvium is sometimes applied to lake and estuary deposits, but is probably incorrectly used in this sense. (See LACUSTRINE DEPOSITS) Unless otherwise noted, alluvium is considered to be unconsolidated. (89, 4, 95)

ANDESITE. A common fine grained volcanic rock in which the soda-lime feldspars (generally andesine) predominate over the alkalic feldspars, and which contains one or more of the dark minerals, biotite, hornblende, augite, etc. Quartz, if present, is hidden in the groundmass. Andesites are the extrusive equivalent of the coarse grained intrusive diorites. They are of many colors, dark-gray being common, and are generally darker than rhyolite and lighter than basalt. They may be so fine-grained as to show no crystals to the unaided eye or may have scattered relatively large crystals set in a fine-grained groundmass. No definition of andesite is widely accepted and in the past the term has been used loosely with a variety of meanings. Andesites are abundant in many regions of volcanic rocks, where they may form extensive flows or more irregular near-surface intrusive bodies. The fresh rock is typically dense, hard, and durable but, as with all rocks, local conditions of fracturing and alteration have more effect on properties and possible uses than does the initial character of the rock. (58, 89)

ANHYDRITE ROCK. A rock composed principally of the mineral anhydrite (CaSO_4). The anhydrite commonly forms beds or seams in sedimentary

rocks associated with gypsum and rock salt. Anhydrite alters to gypsum, from which it differs in crystal form, in being harder, in lacking water of crystallization, and in being somewhat less soluble. It usually occurs in granular to compact masses of white color, but it may be variously tinted by impurities. (4, 59)

APLITE. A fine-grained, light-colored intrusive igneous rock with most of the grains less than one millimeter in diameter. Aplites occur chiefly in dikes, veins, and contact facies of large granitic bodies. The most common type is granite-aplite which consists of quartz and feldspar with which may be associated a little muscovite. Aplites are usually associated with pegmatites, but whereas pegmatites are much coarser in texture than granites, aplites are much finer. (4, 58)

ARKOSE. A special variety of sedimentary rock. It is a sandstone containing more than 25 or 30 percent of feldspar and usually derived from the disintegration of granite or other acidic rocks of granular texture. The mineral composition and shape of the grains (angular, showing cleavage faces of feldspar) indicate that the material has not been subjected to prolonged weathering or to long transport before burial. Arkose is commonly of alluvial origin and its formation is favored by mechanical disintegration of granitic rocks in arid or cold climates. The rock may grade into conglomerates or breccias through increase in size of the component fragments. (58, 4, 76)

ASH. The fine material blown out by volcanic explosions. See
VOLCANIC ASH.

BASALT. A term applied to a group of related fine grained extrusive

igneous rocks that comprise the most common and widely distributed of all lavas. In the general usage, the term includes the majority of fine-grained, dark, heavy volcanic rocks. No strict definition of basalt as a mineralogic or chemical type is yet agreed upon, nor are there definite criteria for distinguishing some basalts from andesites. But most basalts are characterized by consisting of very calcic plagioclase, pyroxene, in many cases olivine, and little or no quartz together with varying amounts of a dark glassy groundmass. Basalt is the approximate extrusive equivalent of the coarser grained intrusive gabbro. It may or may not be porphyritic; and may be quite dense, or filled with many gas bubbles (vesicles), or scoriaceous and frothy, depending on the conditions of extrusion (see AA and PAROEHOE). The more compact varieties find wide use as crushed aggregate, riprap, and rough building stone because of their toughness, hardness, and relatively high specific gravity. Cinders and similar porous varieties are much used for lightweight aggregate because they have low bulk specific gravity yet retain much of the inherent strength of solid basalt. (89, 3, 4, 58)

BASIC ROCK. An igneous rock which has a low proportion of silica (SiO_2) in its minerals. Basalt and gabbro are examples of basic rocks. Such rocks are usually dark in color, as dark gray, green, or black.

BEDROCK. The more or less solid, undisturbed rock in place either at the surface or beneath surficial deposits of gravel, sand, or soil. According to local conditions and usages, bedrock may be soft or hard, consolidated or unconsolidated. Because of the extreme variations that are possible in composition and physical properties the term

should not be used in a technical manner without description of the materials involved.

BLOCK LAVA. Lava having a surface of angular blocks. It is similar in general appearance to aa, but the fragments are more regular in shape and tend to have somewhat smoother faces than those in aa. (4)

BOULDER. A large detached rock fragment, somewhat rounded or otherwise modified in shape by transport. A boulder is larger than a cobble, six inches having been suggested as a convenient lower limit for the diameter. The motion of transportation is usually involved but many large rock masses rounded in place by weathering or partial disintegration have also been called boulders. In general, the manner of origin of a boulder may be indicated by modifiers, as, glacial, river, or disintegration. (59, 8)

BRECCIA. A rock consisting of angular rock fragments larger than sand grains in a cementing matrix. It is like conglomerate, except that most of the fragments are angular with sharp edges and unworn corners. There is no sharp demarcation between conglomerate and breccia, as the shapes of the fragments upon which the distinction rests range from completely round to completely angular. The term should be applied only to consolidated rock; the unconsolidated equivalent is rubble.

There are several common kinds of breccia: (1) friction or fault breccia, which originates through mechanical crushing along fault planes; (2) talus breccia, which arises from the accumulation and consolidation of talus; (3) volcanic breccia, which consists of fragments of rocks ejected by a volcano. The matrix may consist of

material similar to the large fragments, or it may be material deposited from mineral matter in solution. (58, 76)

CALCAREOUS TUFFA. See TRAVERTINE.

CALICHE. A term applied broadly to secondary calcareous rock occurring in a layer or layers at or near the surface - most often used in the arid and semi-arid regions of the United States. Caliche may be a soft horizon of lime accumulation in the soil, but more commonly the term refers to a cemented layer a few inches to many feet in thickness containing impurities of clay, sand, or gravel. The cementing material is essentially calcium carbonate, but may contain magnesium carbonate, silica, or gypsum.

The upper surface is generally undulating, following the surface of the ground, and may show pothole-like depressions. The lower surface may be extremely irregular or gradational with the underlying material. Most caliche deposits are of Pleistocene or Recent origin and appear to form by a variety of processes whereby soil moisture evaporates or otherwise deposits its load of calcium carbonate. Caliche varies greatly in hardness and the resistance it offers to excavation. (4, 89)

CEMENT. The material that binds the particles of a consolidated sedimentary rock together. Various substances may act as cement, the most common being silica, as oxides, calcium carbonate, and various iron oxides.

CHERT. A very dense siliceous rock usually found associated with limestone, either in the form of nodular or concretionary masses or as

distinct beds. No grains can be distinguished with the naked eye, and under the microscope the rock is seen to be made up of micro-crystalline quartz and micro-fibrous "waxy" appearing quartz; sometimes with small amounts of other minerals or organic impurities.

The rock occurs in a variety of colors, perhaps the most common being shades of gray. A variety of chert that is almost identical mineralogically and physically is flint, dark gray to black in color. A red, yellow, brown or black (color due to iron oxides) dense, opaque variety of chert called jasper is associated with iron ores.

Chert is especially tough and resistant and makes up the pebbles in many beds of gravel and conglomerate. It has been much used in the past as an aggregate in construction materials, but its use for such purposes has decreased with the discovery that many varieties possess chemical and physical properties injurious to concrete. (4, 89, 76)

CHALK. A soft, white, fine-grained variety of limestone. It is composed mainly of the calcareous shells of various marine micro-organisms, but the matrix consists of fine particles of calcium carbonate some of which may have been chemically precipitated. (76, 89)

CINDERS. Uncemented volcanic fragments that range from 4 to 32 mm. in diameter (larger than volcanic ash fragments)(89). Such fragments are generally glassy or vesicular.

CLAY. In engineering usage, the term clay refers to a naturally occurring inorganic plastic material made up largely or wholly of particles less than 0.002 mm. in diameter (0.005 mm. is also used as an upper

limit). Mineralogically, clay implies a finely divided crystalline material essentially made up of hydrous aluminum silicates - the "clay minerals".

The so-called clay minerals are alteration products of various minerals, such as feldspar or other silicates. The distinction and grouping of the clay minerals has been made possible largely through developments in X-ray techniques. Three principal groups of clay minerals are now well established. These are: the illites, montmorillonites, and kaolinites.

As a particle-size term, clay has been used variously to denote all mineral particles of less than 0.002 mm. in diameter. Almost invariably clay mineral particles are of even smaller size, but other minerals with totally different physical properties can also occur in micron sizes; these may be referred to as being of "clay size" but it is less misleading to list the size limits. For engineering purposes, all fine-grained materials passing the 200 mesh sieve (less than 0.074 mm.) are classed as clay if they can be made plastic by adjusting the water content, and if the material exhibits considerable strength when air dried. The material is classed as silt if it cannot be made plastic, and if it exhibits little or no strength when air dried. This division is often based upon certain values for the liquid limit and plasticity index. (59, 94, 8)

CLAYPAN. A horizon of accumulated material, or a stratum of stiff, compact, and relatively impervious clay. The claypan is not cemented, and if immersed in water can be worked into a soft mass. Its presence may interfere with water movement or root development; the

same is true for hardpan. It is more difficult to make pervious than hardpan; whereas a hardpan can be shattered by explosives, a claypan, after breaking by any means, will run together and reform as soon as thoroughly wetted. This distinction between hardpan and claypan is important in material classification. (89, 4)

CLAYSTONE. Indurated clay, sufficiently hardened to be called a rock, but not chemically altered or metamorphosed. The mineral composition, color, and occurrences are the same as those of clay. Like clay, it has a peculiar, characteristic earthy odor when moistened by the breath. (87, 89)

COAL. A general name for combustible, solid, black, or brownish-black carbonaceous materials formed through the partial decomposition of vegetable debris. Its formation is distinctly traceable through a series of gradational steps starting with peat and passing through lignite, bituminous coal, and anthracite to a final theoretical limit of nearly pure carbon. It is usually distinctly stratified and is found in association with ordinary sedimentary rocks such as shale and sandstone and more rarely limestone (76, 58)

COLLUVIUM. Heterogeneous deposits of earth material that have moved or been deposited mainly through the action of gravity. Talus and cliff debris are examples of such deposits. (4, 89)

CONGLOMERATE. The consolidated rock equivalent of gravel. The constituent rock and mineral fragments may be of varied composition and of a wide size range. The matrix of finer materials between the larger fragments may be sand, silt, or any of the common natural cementing

materials such as calcium carbonate, silica, clay, or iron oxide. The rock fragments are rounded and smoothed from transportation by water, or from wave action.

Conglomerates are classified in various ways: according to coarseness there are pebble, cobble, and boulder conglomerates; according to origin there are marine, lacustrine, fluvial, and glacial types. Conglomerates may also be designated according to the nature of the constituent fragments: as, granite conglomerate, chert conglomerate, etc. Conglomerates whose fragments have gone through long water transport or much battering by waves usually consist mainly of hard, siliceous rock types such as chert and quartzite. Conglomerates are common in nearly all areas of sedimentary rocks and frequently upon weathering fall apart and give rise to gravel beds of commercial importance. (58, 76)

COQUINA. A term applied to a conglomerate (actually a variety of limestone) consisting predominantly of entire or broken calcareous shells with or without other hard parts of organisms. The constituent shells may be small, ranging down to 2 mm., or may be large fragments of shells several inches in diameter. Coquina is usually very porous, but being strong enough for some structural purposes as well as in road construction. (87, 58)

CORAL. A general name for any of a large group of marine invertebrate organisms which are common in modern seas and have left an abundant fossil record in all periods later than the Cambrian. The term coral is commonly applied to the calcareous or hornlike skeletons left after death of the organism. As found in the fossil state, coral

consists almost exclusively of calcium carbonate. (95, 89)

DACITE. An igneous extrusive rock that is the extrusive equivalent of quartz diorite. In true dacite the quartz should be visible as phenocrysts or recognizable under the microscope in the groundmass. Dacite is included in the general group called felsites. The principal minerals are plagioclase, quartz, pyroxene or hornblende or both with minor biotite. (3, 58, 76)

DIABASE. A basic intrusive igneous rock of the basalt-gabbro series in which the essential minerals are plagioclase and augite with the plagioclase in long, narrow, lath-shaped crystals oriented in all directions and the augite filling the interstices. This arrangement of the constituents is known as diabasic texture. (89, 58)

DIATOMACEOUS EARTH. A soft, siliceous rock material, very fine and porous which consists of pure shells or tests of diatoms (the pure form is sometimes called diatomite). It may originate in either salt or fresh water but is common only in materials of the Tertiary period. The color is commonly white, yellow, or gray and there is a great variation in the amount and nature of impurities that may be present.

Diatomaceous earth can be distinguished from chalk and marl by not effervescing in acid and from kaolin by its gritty feel and

lighter weight. It is widely used in industry as light weight aggregate, filtering agent and absorbent in pharmacology. (4, 89)

DIORITE. An intrusive igneous rock of medium or coarse grain composed essentially of plagioclase feldspar with either hornblende or biotite the chief dark constituent. Commonly feldspars make up more than 50 percent of the rock. A little quartz is usually present and when this mineral is abundant the rock is called quartz diorite or tonalite. Diorites occur as marginal facies about granitic intrusions and also form large intrusive masses, as well as occurring as dikes and sills. It is a more abundant rock type than syenites, but less abundant than the granites. With a decrease of feldspar and increase of the ferromagnesian mineral (hornblende, biotite) so that the rock is more dark than light, the diorites pass into gabbros. (58, 76, 3)

DOLomite. In mineralogy, dolomite is a mineral of definite chemical composition, $\text{CaMg}(\text{CO}_3)_2$. The term dolomite is also commonly applied to rocks approximating the mineral dolomite in composition or consisting predominantly of the mineral dolomite. Although there is every gradation between pure dolomite and pure calcite limestone, those containing appreciable amount of both calcite and dolomite are much less common than those containing more than 80 percent calcite or more than 80 percent dolomite.

As a rock, dolomite occurs in great masses especially in older sedimentary rocks. Most dolomites were probably originally limestones that have been altered by reaction with magnesium bearing solutions. In the field it is not ordinarily possible to distinguish limestone from dolomite by inspection of hand specimens and outcrops.

Dolomite is somewhat harder than true limestone, and if the specimen is a pure dolomite it will dissolve with effervescence only very slowly in cold hydrochloric acid, but if the dolomite is finely pulverized it will effervesce freely in cold acid. Some dolomites have a coarsely porous structure, and fossils are more rare than in limestones. The color of the rock may be white, gray, brown, and sometimes pinkish. (4, 89, 95, 58)

GLACIAL DEPOSITS. Also called glacial drift, it embraces all rock material in transport by glacier ice, all deposits made by glacier ice, and all deposits predominantly of glacier origin made in the sea or in bodies of glacial meltwater, whether rafted in icebergs or transported in the water itself. It includes till, stratified drift, and scattered rock fragments.

As thus defined, drift covers large parts but by no means all of the glaciated regions of the world and extends beyond them along stream valleys and on the floors of lakes and the sea, wherever water could carry drift away from the margins of the glaciers themselves. See TILL. (43, 89, 4, 42)

EOLIAN DEPOSITS. Materials that have undergone transport by wind. They are made up of two distinct types of wind deposits, accumulations of sand and accumulations of silt and clay known as loess. Variations in wind velocities may produce a certain amount of interbedding of the two, but in general they are fairly distinct with loess being found farther leeward from the source area than sand.

Wind deposits are by no means restricted either in origin or location to deserts. Not only is loess found in arctic, humid, or

subhumid regions but eolian sand deposits are common in several non-desert environments. The four non-desert environments in which sand deposits may be found are: (1) along shore lines, (2) along stream courses, (3) in areas where loosely cemented sandstones have disintegrated to supply sand, and (4) in areas of glacial outwash. (95, 92)

ERRATIC. A rock fragment or boulder (sometimes called free boulders), usually of large size, that has been transported from a distant source, especially by the action of glacial ice and floating ice. Erratics are different from the bedrock over which it lies and many of them lie on the surface of till or bedrock, free of any matrix of till. Many are very large; the Madison erratic (granite) in New Hampshire measures 88 x 39 x 38 feet and weighs more than 4,600 tons. (43, 89, 4)

ESTUARINE DEPOSITS. Mixed deposits of organisms and sediments of both marine and fluvial origin; along river channels they grade upstream into typical fresh-water river channel deposits; seaward, they grade into marine deposits, and laterally they grade into deposits consisting of clays, silts, sands, and sometimes peat. (4, 89)

EXTRUSIVE ROCKS. A term applied to those igneous rocks derived from magmas or magmatic materials poured out or ejected at the earth's surface, as distinct from the intrusive or plutonic igneous rocks which have solidified from magmas that have been injected into older rocks at depth without reaching the surface. Synonymous with volcanic rocks. (3, 4)

FANGLOMERATE. Alluvial breccia cemented into rock. A fanglomerate is composed of heterogeneous materials which were originally deposited in an alluvial fan, but which since deposition have been cemented into solid rocks. As originally proposed, the term was not intended to include the finer sediments on the lower flanks of alluvial fans but only the coarser material of the upper parts. (4, 89)

FELSITE. A light-colored extrusive igneous rock having few or no conspicuous crystals and with a groundmass made up of finely crystalline minerals and glass that cannot be determined with the naked eye. This non-committal term is convenient (when tests with a microscope or analysis cannot be made) in field classifications when the more technical discrimination between acidic lavas cannot be made. With the development of a few phenocrysts (large, prominent crystals in the finer-grained groundmass), the determination of the rock is easier. (58, 76, 3)

GABBRO. A dark colored, equigranular intrusive igneous rock which consists of calcic plagioclase, such as labradorite, and one or more dark minerals. The common dark minerals are hornblende, pyroxene, and olivine. Magnetite, ilmenite, and apatite are accessory minerals. Gabbros are probably less abundant than diorite, but underly large local areas as in the Adirondacks and along the west end of Lake Superior. (56)

GEYSERITE. The siliceous deposits, usually consisting of opaline material, formed around some hot springs and geysers. They may be compact, concretionary, or porous, and the deposition may be due to

evaporation or to the effects of algae. It is generally white or light-colored and also light in weight. Geyserite (also called siliceous sinter) is most extensively developed in the United States in the hot-spring and geyser region of the Yellowstone National Park. (4, 89)

GLACIAL DRIFT. See GLACIAL DEPOSITS.

GLACIAL OUTWASH. See OUTWASH.

GLACIAL TILL. See TILL.

GLACIO-FLUVIAL DEPOSITS. Stratified glacial drift that has been deposited by running water. This type of deposit is the principal constituent of kames, eskers, outwash plains, valley train deposits, etc. (4)

GLACIO-LACUSTRINE DEPOSITS. A term referring to lake sediments derived directly or indirectly from glaciers. The deposits made in glacial lakes are of five principal kinds: till in the form of end moraines, deltas, bottom deposits, rafted erratics, and shore features.

The deposits beneath some lacustrine plains consist of alternating pairs of light and dark layers called varves. Each varve pair typically consists of a layer of fine, light-colored sand or silt overlain by a darker clay layer. It is commonly believed that each varve represents a year's deposition, the lighter-colored silty clay layer being the summer layer and the darker clay layer the winter layer. (4, 43, 92)

GNEISS. A term originally applied to a more or less banded metamorphic

rock with the mineral composition of granite. As now employed it designates a foliated metamorphic rock with no specific composition implied, but having layers that are mineralogically unlike and consisting of interlocking mineral particles that are mostly large enough to be visible to the eye. Usually gneiss displays an alternation of granular minerals and tabular or schistose minerals with the rock tending to split along the planes where tabular or schistose minerals predominate. The foliation may be even and continuous or highly contorted and discontinuous, with the individual bands ranging in thickness from a fraction of an inch to several inches.

Gneisses grade directly into schists, but schists generally are finer-grained and show more uniformity of mineral composition and foliation. Gneiss may originate from either igneous or sedimentary rocks and the various kinds comprise the largest group of metamorphic rocks. Various types are recognized; as, granite gneiss, quartzite gneiss, conglomerate gneiss, mica gneiss, and hornblende gneiss. The foliation of true gneiss originates from metamorphism; similar rocks of igneous origin in which the banding is due to magmatic flow before the rock completely crystallized are distinguished as primary gneisses.
(76, 58)

GRANITE. A coarse- to medium-grained, crystalline plutonic rock of predominantly interlocking texture, composed essentially of orthoclase feldspar and quartz. Feldspar is generally present in excess of quartz, and accessory minerals (chiefly micas, hornblende, or more rarely pyroxene) are commonly present, but these accessories seldom exceed 25 percent by volume of the rock. Granite is the predominant

plutonic rock exposed at the earth's surface, and constitutes more than 75 percent of all the rocks in pre-Cambrian terranes. Its origin is in dispute; some is regarded as having crystallized from a melt, some as being derived, without complete fusion, by the intense metamorphism of pre-existing rocks. With increase in the proportion of soda-lime feldspar (plagioclase) to alkalic feldspar (orthoclase) granite passes into granodiorite, and by decrease of quartz into syenite.

The color of granites varies from very light to medium tones of gray, with various shades of pink to red not uncommon. Occasionally green tints are found. (58, 76, 3)

GRANODIORITE. A type of deep-seated, crystalline igneous rock composed of plagioclase, a smaller amount of orthoclase or other alkalic feldspar, quartz, and usually one or more of the dark minerals, biotite, hornblende, or pyroxene. This rock is very similar to diorite except that diorite generally has little or no orthoclase feldspar. (58, 76)

GRAVEL. Loose or unconsolidated coarse granular material, larger than sand grains, resulting from erosion of rock by natural agencies. The lower size limit is usually taken at 2 mm.; the upper size limit is variously defined in different sections of the country. When gravel is used as aggregate for highway construction, three inches is generally considered to be its upper limiting size.

The fragments are usually rounded owing to wear by water action and deposits are most frequently found associated with rivers and beaches. Although almost all rock types will yield gravel deposits,

only the most durable materials will withstand long-continued wear. Gravel is seldom clean, the spaces between the larger fragments being usually filled with clay, silt, and sand. (8, 23, 64)

GRAYWACKE. A special type of sandstone that is the basic equivalent of arkose. It is made up of very slightly decomposed particles derived from basic igneous rocks and their metamorphic equivalents, thus having a large content of ferromagnesian minerals. Some graywackes are massive and show no bedding; others show marked graded bedding and are associated with slate. Graywacke requires an environment in which erosion, transportation, and deposition are so rapid that complete chemical weathering of the materials does not take place, and is a characteristic sediment of belts of mountain making. (87, 58)

GREENSTONE. A field name for rocks that have been so metamorphosed or otherwise so altered that they have assumed a distinctive color owing to the presence of chlorite, epidote, and actinolite. Greenstone is usually derived from dark-colored igneous rocks, such as diorite, diabase, or basalt. Normally tough and hard, it can be crushed to form good to excellent aggregate. The term is useful when no accurate determination of composition or origin is possible in the field. (58, 76)

GUMBOTIL. An ancient soil, developed in till, it is a gray, leached, deoxidized clay, consisting chiefly of the montmorillonite group of clay minerals. It is very plastic when wet and extremely firm when dry. It may contain fragments of more or less altered rock that were originally mixed with the finer particles--mostly the more resistant

siliceous types. The name is a combination of "gumbo", the colloquial term for sticky, clayey soil, and till. (43, 89)

GYPSUM. A hydrous calcium sulfate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), the commonest of the sulfate minerals. Three varieties occur: the colorless, transparent, crystalline variety is selenite; the pearly, fibrous variety is satinspar; and the massive, fine-grained, firm, white or delicately shaded variety is alabaster. Gypsum forms extensive bedded sedimentary rock associated with limestone, marl, and clay, and is often found with anhydrite and rock salt. It also occurs disseminated in many shales and clays, and as surface encrustations from evaporation of sulfate waters. (32, 89, 87)

HARDPAN. A loosely used term designating a relatively hard or impervious layer beneath the soil or in the subsoil that offers exceptionally great resistance to excavation or drilling. As the term is widely used in an essentially popular non-technical manner for a variety of materials, it should always be accompanied by specific information as to occurrence and composition.

More specifically, it is a horizon of accumulation that has been thoroughly cemented to a hard, rock-like layer that will not become soft when wet. The true hardpan is cemented by materials that are not readily soluble, and is a hard layer that (except when fractured or cracked) definitely and permanently limits downward movement of roots and water. The term hardpan is not properly applied to hard clay layers that are not cemented, not to those layers that may seem indurated when dry but soften and lose their rocklike character when wet. The cementing agents may be iron oxide, silica, calcium

carbonate, or other substances. (4, 89)

HORNFELS. A general term for very dense, hard, sugary-grained rocks, no matter what their derivation, that have been recrystallized by the heat of an adjacent igneous intrusion. The conditions of metamorphism have been so uniform that no schistosity has developed and most of the minerals have developed equidimensional or rounded forms. Depending on the original composition of the rock, a variety of minerals, such as biotite, garnet, and feldspar may be formed. (58, 76, 89)

INTRUSIVE ROCKS. Rocks that have consolidated from magma beneath the earth's surface. Same as plutonic rocks.

LACUSTRINE DEPOSITS. Material deposited in a lake environment. The sediments are principally the result of fluvial action, but may be of glacial origin (see GLACIO-LACUSTRINE DEPOSITS). The fine grained sediments of lacustrine origin tend to be well sorted, and most of them are extremely fine grained. The bedding tends to be in very thin units unless the deposit has been subjected to much reworking by organisms. Lake sediments ordinarily contain much organic matter of which some grew in the lakes and some was received via streams and the atmosphere. (89, 4)

LAG GRAVEL. A type of residual gravel composed of very hard rock fragments, usually flints, cherts, quartzites, etc., which are left after long continued wind erosion in desert areas. It is similar to desert pavement. (4, 89)

LAVA. A general name for molten rock poured out upon the surface of the

earth by volcanoes and for the same material that has cooled and solidified as solid rock. Varieties include basalt, felsite, aa, and pahoehoe. (4, 66, 58)

LIMESTONE. A bedded sedimentary rock consisting chiefly of calcium carbonate (CaCO_3) which yields lime when burned. The term has also been used in a broader sense to denote combinations of magnesium carbonate and calcium carbonate. Limestone is the most important and widely distributed of the carbonate rocks and is the consolidated equivalent of limy mud, calcareous sand, or shell fragments. The many varieties of limestone include chalk, coquina, marl, calcareous tufa, caliche, travertine, etc. The percentage of calcium carbonate ranges from 40 percent to more than 98 percent. Common impurities are clay and sand; by increase of clay content limestone may pass into limy shale, and by increase of sand it may pass into limy sand or pure sandstone. The color, due mainly to impurities, ranges from whitish through tones of yellowish to brown, or various shades of gray, dove-color, dark-gray to black. The texture may be aphanitic, fine-grained, or distinctly crystalline. Limestone is practically always of marine origin and the remains of sea-living organisms may be common. It occurs in beds up to 100 feet or more in thickness. Limestone effervesces freely with any common acid, particularly with hydrochloric acid. (89, 58, 76)

LITTORAL DEPOSITS. Deposits laid down near the shore, usually under the influence of wave action. The materials vary considerably, ranging from boulders through gravels, sands, and muds to shells, etc. In some places a single material, such as sand, may extend for miles,

or, the materials may be jumbled together in an extremely irregular arrangement. In general, the coarsest material and materials of highest specific gravity are on the upper part of a beach. Particles in the range from sands to boulders may be well rounded, but also may be somewhat angular. The thickness of littoral deposits for a stationary sea level can be little greater than the tidal range at each place, usually less than 16 feet. Beaches and beach ridges are perhaps the most prominent land forms composed of littoral deposits.
(4, 89, 95)

LOESS. A wind blown, quartzose, somewhat feldspathic, clastic sediment composed of a uniformly sorted mixture of silt, fine sand, and clay particles arranged in an open cohesive fabric.

As defined, loess may contain appreciable amounts of fine sand or clay, or both, but most of the particles are generally within the size range 0.01 to 0.05 mm. The mineral composition is variable, depending on the source of the material. The particles are mostly fresh and angular and are generally held together by calcareous cement or binder. The color of loess is usually light brown, yellow, or gray and the material appears to be homogeneous with little or no ordinary type of stratification. It is very porous, and owing to vertical root holes and fractures it is generally much more permeable in the vertical than in the horizontal direction.

Undisturbed loess has a marked ability to stand in very steep or vertical banks but, if disturbed or saturated, loess loses much of its original shear strength. In many places, the accumulation of loess seems to be associated with past glacial or inter-glacial climates.

(43, 16, 95)

MARBLE. The metamorphic form of limestone, including the dolomites and magnesian limestones, in which the calcite and the mineral dolomite are recrystallized. True marble is a granular crystalline rock made up of calcite or dolomite grains cemented or intergrown and interlocking by additional calcite. It is white; the mottling, banding, and colors of ornamental varieties are due to impurities such as oxides of iron and organic matter. As the ordinary varieties are composed of calcite they will effervesce readily with dilute hydrochloric acid; the dolomitic varieties will effervesce only if the acid is applied to a fresh scratch. Marble deposits are usually found in regions of intense metamorphism, and associated with gneiss, schist, etc. (89, 4, 58)

MARINE DEPOSITS. Deposits laid down in the sea, usually beyond the seaward edge of the littoral belt.

MARL. An old term loosely applied to a variety of materials most of which occur in loose, earthy, or friable deposits and contain a relatively high proportion of calcium carbonate and dolomite. It is used in the Coastal Plain area of the United States to denote fine-grained calcareous sands, deposits of unconsolidated shells, calcareous clays and silts, and sediments containing glauconite. The term is also applied to the deposits of lakes in glacial regions in which the percentage of calcium carbonate may range from 90 to less than 30 percent. Usually marl is gray, but yellow, green, blue and black varieties are also found. The term should probably not be used

without a more complete description of the material. (89, 4)

MINERAL. An inorganic substance occurring in nature, though not necessarily of inorganic origin, which has (1) a definite chemical composition or, more commonly, a characteristic range of chemical composition, and (2) distinctive physical properties or molecular structure. With few exceptions, such as opal (amorphous) and mercury (liquid), minerals are crystalline solids.

Minerals can be readily identified by their physical or chemical properties, the variations in these properties being within rather narrow limits. Of these two, the more easily determined properties are those termed physical. Through inspection and simple tests, various properties may be found, such as: color and streak, cleavage and fracture, hardness, luster, and structure.

Only eight of the 100 plus elements are combined to form some 98 percent of the observable portions of the earth. The most common minerals are composed of these elements and are often called the common rock-forming minerals. (32, 89) A brief list of these rock-forming minerals are as follows:

Silicates: Chlorite, Feldspars, (orthoclase, plagioclase), Amphiboles (hornblende), Micas (muscovite, biotite), Olivine, Pyroxenes (augite), Talc, Serpentine, Zeolites

Oxides: Corundum, Hematite, Ilmenite, Limonite, Magnetite,
Quartz

Carbonates: Calcite, Dolomite

Sulfates: Anhydrite, Gypsum

MUCK. A dark-colored combination of inorganic mineral matter and fairly

well decomposed organic material (often decayed peat) that is accumulated under poor drainage conditions. (4, 89) See PEAT.

MUDSTONE. A general term for consolidated mud or clay that shows little or no tendency to break into thin layers as does shale. Mudstones include clay, silt, and shale. It should be used only when there is doubt as to precise identification or when a deposit consists of an indefinite mixture of clay, silt, and sand particles, the proportions varying from place to place, so that a more precise term is not possible. (58, 87, 89)

OBSIDIAN. An old term for dense, clean, hard volcanic glass. Most obsidians are black although red, green, and brown ones are known. They are often banded and normally have conchoidal fracture, a glassy luster, and are translucent in thin pieces. The name has in recent years been somewhat restricted to glasses having a very low water content as contrasted with pitchstones and perlites. Most obsidians are rhyolitic in composition. (58, 76, 3)

OUTWASH. Stratified drift deposited by meltwater streams beyond active glacier ice. Outwash is characteristically coarse grained and well sorted, and is stratified in thin courses of foreset beds. Variations in grain size are sharp and numerous both horizontally and vertically. Ordinarily there is a wide range of grain sizes, from boulders down through sand. The silt and clay fraction is small or absent, having been carried downstream as suspended load beyond the recognizable outwash body. The outwash deposits represent bed load continually dropped out, with decreasing grain size in the downstream direction.

Outwash plains and valley trains are probably the most prominent land forms composed of outwash. (43, 89)

PAHOEHOE. The Hawaiian word for solidified lava that is characterized by a smooth, billowy, or ropy surface having a skin of glass a fraction of an inch to several inches thick. Pahoehoe is distinguished from the aa type by its smooth surface, and probably also by such internal characteristics as higher content of glass, and by the gas bubbles being more numerous, more spheroidal, and having smoother walls. Pahoehoe flows often contain large open or partially filled lava tubes which served as under surface conduits for the advancing lava. (3, 89)

PEAT. A dark-brown to yellowish matted mass of semicarbonized plant material in which remains of leaves, twigs, stems, and roots are discernible. The plants entering into the composition of peat are those that grow in swamps and marshes; mosses, sedges, trees, etc. Although there may be a large proportion of inorganic material, true peat, because of its high carbon content, will ignite and burn freely when dry. The places where peat forms are often called peat bogs. (4, 89) See MUCK (Also see Organic Terrain, page 79).

PEGMATITE. A very coarse-grained igneous rock. The term is sometimes restricted to a coarse-grained light-colored feldspar-rich granite. However, at present, the use of the term has been extended to include a variety of crystalline igneous rocks characterized chiefly by large average grain size, interlocking texture, and especially by unusually great range in grain size. The range in grain size may be as much

as from a millimeter to tens of feet within a small area. Pegmatites are commonly associated with large bodies of plutonic igneous rock of somewhat similar composition. They are commonly in the form of dikes and sills, but may be irregular. Composition of the group as a whole ranges from very acidic to very basic (See Table 3), and qualifying terms may be added to pegmatite to indicate difference in composition. (58, 76)

PERIDOTITE. An intrusive igneous rock of very low silica content having a granitic texture and composed mainly of olivine with or without pyroxene, amphibole, and mica. Feldspar is absent or present only in small amounts. Peridotites occur as segregations in gabbroic rocks and in small intrusive sills, dikes, and stocks. Many varieties are named according to the kind of pyroxene or amphibole present. One of the most common peridotites is dunite which contains 90 to 100 percent olivine. Commercial deposits of iron ore, chromite, platinum, and diamonds are associated with peridotites. A characteristic feature of peridotite is the tendency to alter to the dark-green rock serpentine. (58, 76)

PHYLLITE. A fine-grained foliated metamorphic rock intermediate between the mica schists and slates, into which it may grade. The cleavage is made possible by the development of a large amount of the potash mica, sericite, which also gives the rock a distinctive silvery appearance. Between the cleavage planes minerals other than mica usually predominate and garnet and pyrite may occur in visible crystals. Phyllite is usually light in color but various darker shades, even black, are found. Practically all phyllites are derived

from fine-grained sedimentary rocks by mechanical deformation and recrystallization. A few have been formed from felsite and tuffs. The fracture is intermediate between the smooth, even cleavage of slate and the rather splintery fissility of schist; the rock is not as tough as slate. (56, 76)

PORPHYRY. An igneous rock containing a considerable proportion, 25 percent or more by volume, of larger crystals (phenocrysts) set in a finer groundmass of small crystals or glass or both (porphyritic texture). The rock name applicable to the groundmass part of the rock is usually prefixed to the word porphyry such as rhyolite porphyry. The term is not generally applied to porphyritic rock with coarsely granular groundmass or which contain only a few scattered phenocrysts. (56, 89)

PUMICE. An excessively cellular, glassy lava, generally of the composition of rhyolite. It is generally so light and frothy that it will float on water. The open spaces are minute vesicles formed originally by the expulsion of water vapor or other gas from highly heated lava. When formed the glass is so pasty and viscous that the minute bubbles retain their shape without collapsing during and after cooling. Pumice may be white, gray, yellow, brown, or red in color. The luster is silky or vitreous. If pumice has been blown to bits by the force of volcanic explosion so that the cells are broken, the material is known as pumicite. This distinction is not always adhered to, especially in commercial terminology. Block pumice is widely used as an abrasive. In crushed form it has found wide use as lightweight concrete aggregate, as insulation, and in acoustic tile and

plaster. (58, 76, 89)

QUARTZ DIORITE. See DIORITE.

QUARTZITE. A metamorphic rock derived from sandstone, composed dominantly of quartz. It is characterized by such thorough inundation that the rock breaks through individual grains, rather than around them, leaving a smooth vitreous surface. These qualities result from an abundant siliceous cement which is crystalline quartz, and which is commonly deposited around the grains of the original sandstone, enlarging the quartz grains so that they are interlocked with adjoining grains. The filling of the pore spaces may result through deposition of quartz from circulating ground water, or by recrystallization under heat or stress in metamorphism. Quartzite is usually light in color, but may range through various shades of brown and red, is very hard and resistant to abrasion, and is impervious. (58, 76, 89)

QUARTZ MONZONITE. A rock of granitic texture, intermediate in composition between granite and quartz diorite, which contains quartz and about equal amounts of orthoclase and plagioclase feldspars.

RHYOLITE. An igneous extrusive rock having essentially the same

chemical composition as granite (the extrusive equivalent of granite). It is usually porphyritic but may be fine-grained or vitreous. The essential constituents are quartz and alkalic feldspar; biotite, hornblende, and pyroxene may or may not be present. Flow-banding is frequently conspicuous. The color may be white, gray, pink, red, or purple. The size and prominence of the phenocrysts varies greatly, there being a complete gradation from porphyritic to nonporphyritic rhyolite. The extremely glassy type is called obsidian and if the rock is so fine-grained that mineral composition cannot be determined in the field it may be called felsite. (58, 76)

ROCK FLOUR. Very finely ground rock material of silt and clay size formed by the abrasive action of glaciers. It consists predominantly of angular, unweathered mineral fragments and thus does not possess the cohesion characteristic of fine grained materials composed of clay minerals. Rock flour is common in glacial outwash stream and lake deposits. See SILT. (89, 4)

ROCK SALT. Common salt, NaCl, occurring in the solid form as the mineral halite. When pure it is transparent and colorless, but frequently it is stained by iron or mixed with fine mechanical sediments. It occurs in beds, some of which are of enormous extent, in the sedimentary formations, and is generally accompanied by gypsum and anhydrite. More remarkable even than the great salt beds are the intrusive plugs and stocks of salt up to 40 square miles in area that occur in the Gulf Coast region of Louisiana and Texas, as well as Germany, Iran, and other places. (89, 4, 87)

SAND. An aggregation of unconsolidated mineral or rock particles the diameters of which are usually considered to be less than 2 mm. and more than 0.074 mm. (#200 U. S. Standard sieve). The term thus refers to size of grain and not to composition. As most sands are composed of quartz, when the term sand is used without qualification a siliceous composition is implied. Other varieties include gypsum sand, coral sand, shell sand, magnetite sand, olivine sand, and glauconite sand. Some 200 sand-forming minerals have been listed.

Material finer than sand is called silt or clay, coarser material gravel. Large sand grains are apt to be rounded; the finer grades are usually somewhat angular. Although the term has often been restricted to only material produced by the natural disintegration and erosion of rocks it is also applied commercially to fragments formed by crushing either natural or artificial materials.
(8, 23, 64)

SANDSTONE. A consolidated rock composed of sand grains cemented together. The size range and composition of the constituents are the same as for sand and the particles may be rounded or angular. Although sandstones may vary widely in composition they are usually made up of quartz, and if the term is used without qualification a siliceous composition is implied. Coarse sandstones grade into conglomerates, fine-grained sandstones into siltstones and shales. For practical purposes in the field any clastic rock in which the individual grains are visible to the unaided eye or slightly larger may be called a sandstone.

Sandstone fractures around the grains rather than through them as in quartzites; the broken surface of a sandstone therefore has a

gritty feel and loose grains are usually present. The cementing materials are silica, calcium carbonate, clay, and the oxides of iron; siliceous cement produces the strongest and most durable sandstones. The cementing material is usually introduced by ground water after burial of the sand itself. (87, 58, 89)

SCHIST. A crystalline metamorphic rock that has closely spaced foliation and tends to split readily into thin flakes or slabs. There is complete gradation between slates and schists on one side and schists and gneisses on the other. In general, however, schists show a coarser texture and a more evident crystallization than slates and they have a higher proportion of secondary minerals and a more regular and closely spaced lamination than gneisses. The principal mineral grains are visible to the naked eye and there may be scattered large crystals, simulating the phenocrysts of igneous rock. Usually the rock splits along the planes in which the readily cleavable minerals are concentrated. The foliation surfaces are even and more or less rough and if crumpling or puckering has taken place it may be impossible to split the rock along well-defined planes. Many varieties are recognized with names based chiefly on the mineral responsible for the foliation; as, biotite schist, muscovite schist, hornblende schist, chlorite schists, etc. Feldspar is less common than in the gneisses. (89, 58, 76)

SCORIA. Rough, cinderlike, more or less vesicular lava thrown out by an explosive eruption or appearing on a lava stream. The expansion and escape of enclosed gases produce the typical structure. The term is usually restricted to basaltic or closely allied lavas. The

term scoriaceous applies to the rock texture or appearance. (4, 89)

SEDIMENTS. Deposits of solid material (or material in transportation that may be deposited as solid) formed on the surface or in the outer crust of the earth under normal temperatures. The term is applied to all kinds of deposits from the waters of streams, lakes, or seas, and in a more general sense to deposits of wind and ice. Such deposits that have been consolidated are generally referred to as sedimentary rocks. (89)

SERPENTINE. A term applied to both a mineral and a metamorphic rock.

The mineral serpentine is a hydrous magnesian silicate that is usually compact but may be granular or fibrous. It is fairly soft, has a dull or greasy luster, and its color varies from green through black, brown, or white.

The rock serpentine is essentially an impure form of the mineral serpentine in which there are varying quantities of other minerals such as olivine, pyroxene, amphibole, and pyrite. It is secondary in origin, being derived mainly from primary rocks rich in olivine. The fibrous form of serpentine, chrysotile, is the principal source of asbestos. (58, 76)

SHALE. A general term for lithified muds, clays, and silts that are fissile and break along planes parallel to the original bedding. A typical shale is so fine grained as to appear homogeneous to the unaided eye, is easily scratched, and has a smooth feel. Shale differs from mudstone, claystone, and siltstone in the possession of marked fissility. The change of loose sediment to shale is attended

by compaction, some degree of recrystallization of the constituents, and usually an enlargement of particles.

By metamorphism shales may become slates, but in slate, the cleavage usually lies at an oblique angle to the original bedding and is a secondary development.

Shales vary in color, shades of red, brown, gray, and green as well as black being common. They are usually divided into varieties according to the mineralogic compositions; as, argillaceous, diatomaceous, ferruginous, glauconitic, gypsiferous, sandy, siliceous, and silty. Shales are thought to be the most abundant of the three common types of sedimentary rocks. (37, 4, 89, 87)

SILT. In a general and non-technical sense, the muddy, fine sediment carried or laid down by rivers or by the ocean in bays and harbors. In a more technical sense, silt generally applies to unconsolidated material finer than sand and coarser than clay, but there has been little agreement in the past on the size limits.

As used in the past, the term carried no implication as to mineral composition, but there is a growing tendency among engineers to classify fine-grained soils according to their physical properties and, therefore, to a considerable degree upon the presence or absence of plastic clay minerals. Thus, silt is defined as the material passing a No. 200 sieve (.074 mm.) provided it cannot be made plastic by adjusting the water content, and if it exhibits little or no strength when air dried. (8, 23, 64, 89)

SILTSTONE. Silt that has been converted to rock. It is intermediate in grain size between sandstone and shale. The coarser shales, in

which minute quartz grains are abundant enough to give the rock an appreciable gritty feel, can be classified megascopically as siltstone. Generally siltstones are considered to have little if any bedding cleavage. See MUDSTONE. (87, 89)

SLATE. A homogeneous, metamorphic rock, so fine-grained that no mineral grains can be seen. Most slates are blue-black, a shade so typical as to be called slate-colored, but many are red, green, gray, or black. Slate splits with a foliation so perfect that it yields slabs having plane surfaces almost as smooth as the cleavage planes of minerals; hence this variety of foliation is termed slaty cleavage. This slaty cleavage lies at an oblique angle to the original bedding of the shale from which it has formed, and is a secondary development.

Slates grade into phyllites on one side and into shales on the other. The distinguishing differences from shales are as follows: surfaces of shale are generally dull, whereas slate has considerable luster. Slate is generally somewhat harder than shale, although not always. Most slates ring when struck a light blow, whereas shales do not. (58, 76)

SYENITE. A crystalline plutonic rock, resembling granite in appearance, but containing little or no quartz. Syenites consist mainly of orthoclase (80 to 85 percent), small amounts of plagioclase, and usually some dark mineral such as hornblende, biotite mica, magnetite, and augite. Syenites are not as widely distributed as granites and are found only in small bodies, often as local facies of larger bodies of granite, or as small dikes. (89, 58)

TILL. That part of glacial drift deposited directly by ice, without transportation or sorting by water, consisting generally of an unstratified, unsorted, unconsolidated to moderately consolidated, heterogeneous mixture of clay, sand, gravel and boulders. The term boulder clay has also been used for till, but is not recommended because some till contains no boulders, some contains little or no clay, and some (although not much) contains neither boulders or clay, but only silt, sand, and pebbles. A wide range in grain size is typical, although the dominant size and mineralogic and lithologic composition is determined in large part by the rocks from which the till was derived. The consolidated equivalent is called tillite.
(43, 4, 69)

TILLITE. A glacial till that has been indurated. The term is reserved for pre-Pleistocene tills that have been indurated or consolidated by processes acting after deposition. It is generally unstratified and consists of a chaotic assemblage of angular, subangular, and rounded fragments to huge boulders. Generally the matrix in which the rock fragments and boulders are enclosed predominates in volume. Tillite is likely to resemble a cemented alluvial breccia, or conglomerate. In fact, tillite can be distinguished from conglomerate only by finding in it faceted and striated stones of glacial origin, or by finding that it rests on a glaciated floor.

TRACHITE. A light-colored extrusive igneous rock, either finely crystalline or glassy, composed essentially of alkalic feldspar and more or less biotite, amphibole, or pyroxene. The intrusive equivalent of trachite is syenite. The term was formerly applied to lavas that

are rough to the touch and thus included rhyolites, andesites, and trachites. In older reports the term should be understood to cover a variety of rocks that would now be classified more specifically.

TRAP ROCK. A term originally applied to igneous rocks that are neither coarsely crystalline nor cellular. It is still used in a general and non-committal sense by engineers and geologists for dark colored, heavy, igneous rocks composed essentially of ferromagnesian minerals, basic feldspars, and little or no quartz. Among the specific rock types included under the term are: basalt, peridotite, diabase, and fine-grained gabbro. The term is commonly employed for such rocks used in road making. (4, 69)

TRAVERTINE. The rock formed by deposition of calcium carbonate from solution. When deposited slowly, as in stalactites and stalagmites in caves, it is rather hard and compact, fine crystalline, sometimes white but usually tinted yellowish or brownish. It often has a fibrous or concentric structure and breaks with a splintery fracture. Also found in caves, Mexican onyx is usually deposited on flat surfaces in contrast to stalactites and stalagmites.

When deposited more rapidly, as by springs, it is softer, not evidently crystalline, and porous to loose or earthy. Calcareous tufa (or calcareous sinter) is a variety of this type. (58, 76)

TUFA. See TRAVERTINE.

TUFF. A rock composed of indurated pyroclastic material, consisting wholly or predominantly of fine-grained volcanic ash or dust. Some fragments of country rock, or minor amounts of fragments larger than

4 mm., may be present. Tuff may or may not be deposited in water, and it may be well sorted or heterogeneous; if transported and re-deposited by water the product is tuffaceous sandstone or shale.

(58, 76)

TUFFITE. A general term for composite clastic rocks, in which both volcanic and detrital materials are present in considerable amount.

VOLCANIC ASH. The unconsolidated fine-grained material thrown out in volcanic eruptions. It consists of minute fragments of glass and other rock materials, and in color and general appearance may resemble organic ashes. The term is generally restricted to deposits consisting mainly of fragments less than 4 mm. in size. Very fine volcanic ash, composed of particles less than 0.05 mm. in size, may be called volcanic dust. The indurated equivalent of volcanic ash is tuff. Ash deposits vary from poorly to well stratified, and may be very small or quite extensive in the horizontal direction. (95, 4, 89)

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